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THE WATER WORKS FROM THE VIEWPOINT OF THE ARCHITECT[1]

By V. A. Matteson[2]

While not a waterworks engineer, the speaker does not feel himself entirely out of the circle this evening, for, if not mistaken, he is the only member of the American Institute of Architects who has the honor of holding membership also in the American Water Works Association. A rather close contact with the design and construction of waterworks buildings during the past twenty years is perhaps accountable for this pleasant connection.

It is scarcely conceivable that it should be necessary to point out to a body of men, such as are the members of this Association, the importance of the water works. However, in view of what is still to be seen quite frequently, its importance is not always indicated in its architectural expression. In time the public gets used to almost anything, and accepts as a natural consequence the construction of uninteresting looking buildings for almost any purpose. Architects, as a class, are familiar with this situation, and feel that the keeping of a high standard of architecture is in their charge. Engineers no doubt have the same feeling with regard to the work of their profession. There is this difference, however, in that bad engineering is sometimes fatal, and there is more compulsion in connection with

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good engineering design than in that phase of architectural design which affects appearances only.

Such being the case, architects feel the necessity of doing a certain amount of missionary work, for few others will take the trouble to point out the difference between the good and the bad. When the public knows what it wants, it is usually successful in getting it, and it seems certain that this applies to the appearance of waterworks buildings. It is probably for want of sufficient missionary work along these lines, that the people do not demand in all cases that the water works shall be housed in buildings that have been given the intelligent consideration architecturally which their importance warrants.

As a first step in this missionary work, it would be well to point out to the general public the real importance of the water works. It should be shown that it is of more importance than any single manufacturing plant for purely commercial purposes, and, in fact, of more importance than any single public utility, or of any public building housing executive departments. It should be shown that it may be a thing of beauty as well as purely utilitarian.

From the advent of man, he has from necessity located his habitation near a source of water. Water, food, and protection, now, as then, are the three prime necessities of life, and of these water is of first importance. Cities or towns can only exist where water is available or can be procured, to quench thirst, for the preparation of food, sanitation and fire protection. Without water all other considerations may be set aside, and nothing is of more serious consequence than the failure of the water supply. The visible structures housing and protecting the water supply apparatus, and their necessary adjuncts, therefore, should be given that consideration, architecturally, in proportion to their importance as compared with structures used for other purposes. The public ordinarily expects, and demands, attractive and even lavish public buildings. State capitols, court houses, city halls, libraries—even jails and fire department buildings—are customarily given such consideration architecturally, with more or less success, and frequently no expense is spared in their embellishment. Still any or all of these could be put out of commission, without serious consequence to the community, for a considerable period.

It is argued that in many cases the source of supply is so located that the pumping station and allied works may not be placed in the better section of the community; that it is frequently remote, or in the

worst section; that to expend money for ornamental purposes in such locations would be a waste. That is an open question. It may be true in some cases, but in general I think that there is no spot in any city or town so humble that it cannot be improved. Why add to existing ugliness? Left alone, nature is seldom ugly, but man makes it so. He should restore it either to its natural condition or artificially make it no less beautiful than nature left it. Having restored it, let him make his work pleasing thereafter. It has also been repeatedly found that the poorer quarters of a city can be improved; that the inhabitants will lend a helping hand if given an example and shown the way. All such improvements lead to better citizenship.

It sometimes happens, due to a too prevalent idea that a waterworks building must be of an objectionable factory type, that no such structure should be located in the residence districts, for fear it would spoil the neighborhood. There is, of course, no real reason why such an idea should prevail, nor why such a construction should be objectionable in fact, other than a rather unfortunate precedent for just such objectionable structures actually built. It is just as possible to make such a building in keeping with its surroundings, as to do so with any other sort of building. A gully in a park, in a beautiful residence district, but difficult and expensive to fill up, might be utilized for a filter plant and pumping station, the superstructures of which might be made as attractive as any park pavilion. There are many ways of doing it. Figure 1 illustrates one method.

The coöperation of a waterworks board or other governing body having the interests of the community at heart, in ways other than saving money, is of great advantage, but it is not always necessary to add greatly to the expenditure. Taxpayers do not want their money wasted, but they do want their money's worth. There is an increasingly large proportion of the public who realize that the worth of a thing is affected, among other considerations, by its appearance.

In general, of the amount of money expended on a complete water system only about 25 per cent of the total is applied to works above ground and visible. While it is of prime importance that the hidden portions be properly constructed and designed, it is logical to maintain that the small proportion which can be seen should be not only as well constructed and properly planned, but should, in addition, present an attractive appearance as judged by the highest standards. These three items, namely: good construction, good arrangement,

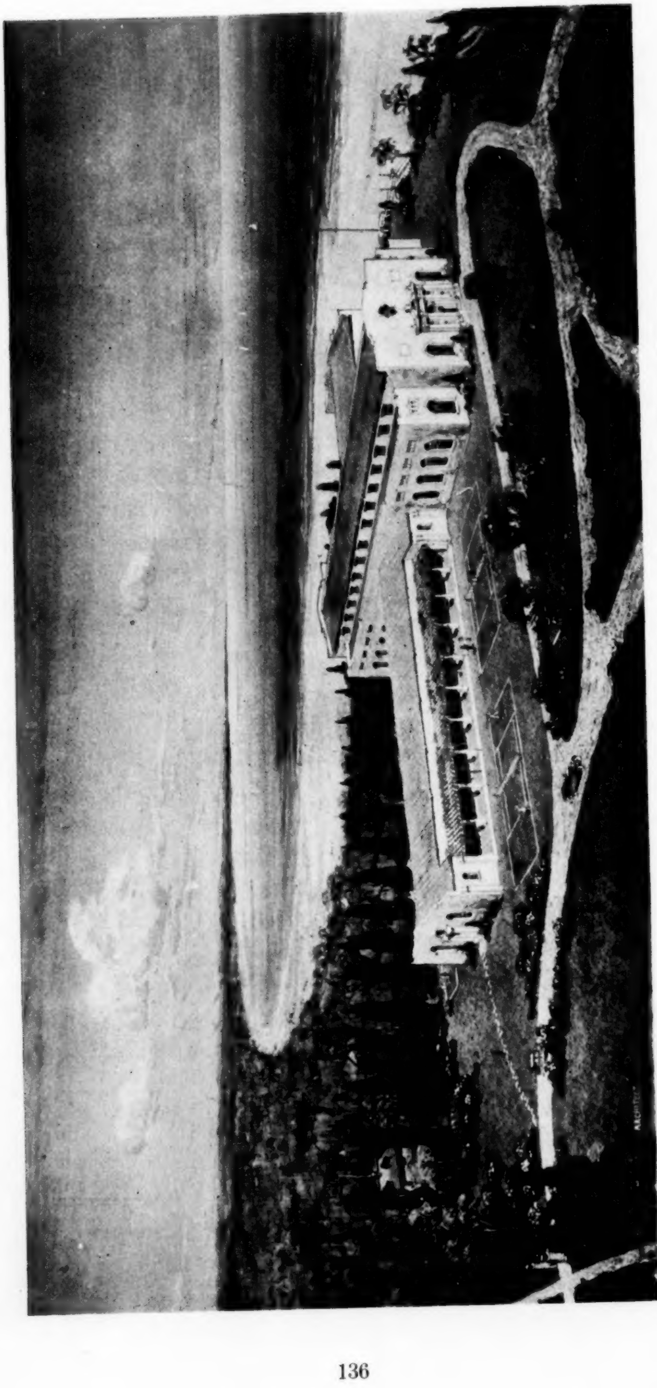


Fig. 1. A Water Works and Filtration Plant in a Park Setting

good appearance, all as judged from the best standards, form three essentials of good architecture.

It will be pointed out later that of the small visible portion of the total investment (the possible 25 per cent)—the added cost necessary to make the difference between attractive appearance and the reverse—is so small that the added cost of the total investment would be a matter of a few per cent; in some cases as low as 1 or 2 per cent. In other kinds of public work, where the greater expense is entirely above ground and visible it is a commonly accepted custom to expend a considerably larger percentage for beautification, and this is fortunate. If everything in the world were to be built along lines of strict utility and economy, without any sacrifice whatever to beauty, the world would be a dull place to live in for most people.

Fortunately, it is inherent in human nature to love the beautiful, and to demand it. This is being more and more realized by public bodies, and many cities are spending great sums in tearing down the ugliness, condemning property, and reclaiming land for improved streets, parks, playgrounds, etc., and an attempt is being made in all of these to make them beautiful. City planning is being attempted on a large scale, and beauty is one of the important items in all of these plans. The water works, even when privately owned, partakes of the nature of a public utility, and the buildings and grounds lend themselves very nicely to an important place in this scheme.

The increased cost of a project resulting from an intelligent consideration of the appearance is not necessarily large. In some cases where a certain amount of what is commonly called "ornamentation" is contemplated, there is no difference between the cost of a well designed result, and one which is badly designed. It is sometimes said that it does not cost more to build a beautiful thing than an ugly one. I cannot hold that this is always true. It usually does cost more; but the point is that the increased cost need not be great, and a part of this cost lies in the cost of the application of thought, study, and experience on the part of those in charge of the designing and execution of the work.

It is futile to design a beautiful building and set it amidst ugly surroundings. Just as a chain is no stronger than its weakest link, so a building can be spoiled by its immediate surroundings. A comparatively simple structure, if not offensive, can often be made to seem attractive by suitable surroundings, and the absence of offending features. The reverse is also true.

Perhaps the two greatest difficulties to be overcome in the design of an attractive water works is the water tank and the stack. It is practically impossible to design a very large exposed steel water tank that will not be a blot on the landscape. Figure 2 is an illustration of such a tank. The picture was actually taken for the purpose of showing the rather queer looking elevator-like building which adjoins the tank. It is an elevator in which an attempt has been made to give it a Spanish effect, to harmonize it with other Spanish type buildings in the vicinity. The building contains bins for lime and other chemicals used in a softening plant and filter near by. The ground floor contains machinery and the second is an operating floor.

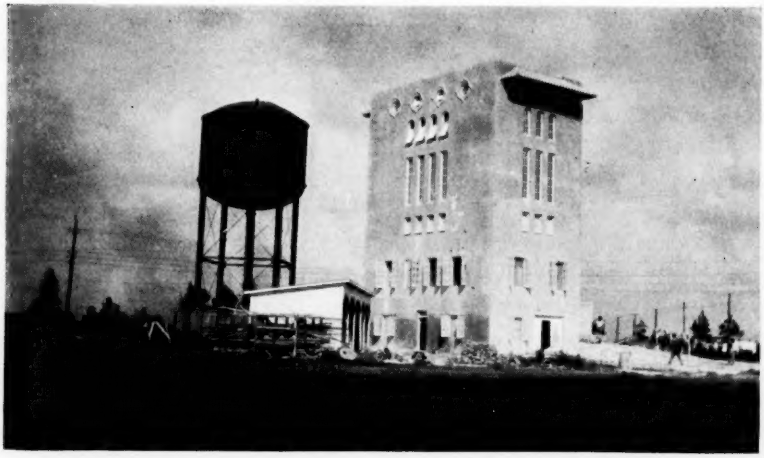


FIG. 2. EFFECT OF A BUILDING SPOILED BY A STEEL TANK

We are so familiar with the appearance of these tanks that it is hardly necessary to illustrate them. They are so familiar that I fear we are getting used to them, and accepting them as inevitable. These exposed steel tanks may be good engineering, and they may be good economy, but as yet they have not demonstrated their beauty, and I doubt whether their ugliness is justified. The Romans, who were good engineers of their day, made their aqueducts good-looking. Ultimately I believe these steel tanks will disappear. In one case in mind, the authorities, recognizing the ugliness of a large steel wash water tank, and realizing that it would destroy the effect of any merit the building might have, have located it at some distance, on the side of a hill, where the trees hide it, and the hill masks it considerably

and hides it completely from some directions. Where steel tanks must be exposed, it seems reasonable to go to some expense to locate them at a distance, if by so doing they may be somewhat hidden,

FIG. 3. SUCCESSFUL TREATMENT OF TOWER ENCLOSING A STEEL WATER TANK

and removing them from close proximity and competition with the building. Such an expenditure is just as justifiable as one for ornamentation on the building itself; in fact, in case of fixed limitations,

I would advocate the omission of some item such as extra cut stone, if by so doing the tank could be removed from close proximity to the building and hidden. In some cases the wash water tanks of filter plants may be incorporated in the building design.

An expenditure for enclosing high tanks when they may not be located in a manner that would render them less objectionable, is justified on the score of looks, although there is nothing economical about it. The enclosure acts as a protection to the steel, prevents condensation, prevents freezing, and can be used as a support, so it has some practical use, in addition to that of hiding the nakedness of the tank and supports. A similar arrangement is shown in figure 3.

In a tower structure it is a rather difficult proposition, usually, to secure a pleasing proportion, due to the fixed relations between the width and height necessitated by the storage and pressure requirements. With these proportions fixed, the designer is compelled to resort to various expedients in order to secure an appearance of slenderness and grace, which are not inherent in the natural proportion of the structure. In this case apparent relative height is given by means of the vertical angles of the polygonal shape of the shaft. Pilasters and panels, as in the former illustration, and even windows, may be useful to this purpose, when properly used.

A tower designed by the speaker, but not built according to this design, may be used as an illustration of the difficulty, even when considerable expense is under consideration in the execution of the design. The height was limited naturally by the water pressure, and an attempt was made to increase the apparent height by means of a pitched high roof. Nevertheless the effect was top-heavy, due to the lack of shaft between the base and the ornamental feature, which corresponds to the capitol of a column. A tower usually is designed as a shaft, with base and cap. This was the case in this instance, but the effect was of necessity altogether too short for the base and cap, and the proportions of the latter were more or less fixed by the diameter. It would have been impossible to have improved the tower by changing details, and retaining the principle of this design

Round towers are difficult. While in such a structure as a tall lighthouse a circular structure may be pleasing at times, they are to be avoided when the structure is relatively short, as compared to the diameter. The old-fashioned standpipe, which provided an opportunity for a graceful shaft, gave the architect a much better chance in the design, although at the time they were being used

extensively, there were apparently few good designers given an opportunity to make of them what their possibilities warranted.

FIG. 4. AN OLD, WELL-DESIGNED WATER TOWER

The chimneys are in harmony with the building and therefore not conspicuous.

An excellent example of familiar tower of this nature is one of the exceptions. While serving no practical purpose I believe at present, it is being carefully preserved, not only as a historic landmark but as a beautiful piece of architectural work of its style. It is shown in figure 4.

It is of interest to note in passing, that in connection with the pumping station which adjoins the tower, the chimney is of the same stone as that of the tower and building, and the design matches that of the building. Due to the proximity of the standpipe-tower, and the numerous turrets with which the building is adorned, the chimney is not particularly prominent, and in no way objectionable. In this case the chimney has been successfully handled.

It might be well at this point to touch on the question of architectural styles briefly, but more will be said later. The question of the so-called "style" of architecture should be a matter of appropriateness rather than one of individual preference. While many people, including many architects, have strong individual preferences for one style or another, it cannot be said that one style is bad while another is good. There may be very good design in a style which may not please the individual. The question of individual taste in style is largely a matter of what one is familiar with, and of personal psychology. *The matter of good and bad design, however, is a question of knowledge, ability and opportunity on the part of the designer, and of knowledge on the part of the critic.* A good designer would hardly attempt to make a Greek tower of a structure of the proportions of the one illustrated, and in all probability he would be properly criticized if he did. It is difficult to imagine him successful in the attempt. Yet there is nothing bad about Greek architecture. On the other hand, the Gothic style lends itself well to the problem. In this case the proportions and outline of the structure are excellent. The details may be subject to criticism, but, fortunately, they are not all important and time has mellowed their faults in this case. After all, details do not make the design, a point which is very frequently overlooked, especially by incompetent or amateur designers.

We now come to the other feature of the water works which is a difficult one from the architectural point of view: the chimney. I am now treading on somewhat dangerous ground. The difference in cost between the simple concrete, radial brick or steel stack, as compared with a stack in harmony with the building which it adjoins or emerges from, is such that one of the cheaper constructions is

usually adopted, even though much thought, time and money may be spent on the design of the building. It is sometimes suggested in apology for the appearance of the stack, that it should be accepted in its nudity as a necessity. This idea is expedient rather than artistic. The stack should harmonize with the building, or the building with the stack. If a plain stack must be adopted, why not also make the building plain? An ornate building cannot possibly detract from the ugliness of an ugly stack, no matter how good in design the building may be. On the other hand, it is conceivable that a building might be plain and honest, as well proportioned as the conditions will permit, and still be in harmony with the stack, with a resulting unity of color, material and form, which in themselves will give a result not displeasing.

I can do no better than to quote from "Power House Engineering" of October, 1925, describing such a stack:

> Chimneys to give draft must reach upward, like church spires or memorial towers. In house architecture the chimney is used as an effective part of the ornamentation without detracting from its usefulness. In churches and many public buildings towers and spires are used for their beauty alone. Why should not the power plant chimney—(and I will add, the water works chimney)—be a delight to the beholder as well as serving its prime purpose?
>
> This chimney was planned by the architects to harmonize with the buildings, to add to the attractiveness of the grounds, and to give the needed draft to the boilers. It is 175 ft. high, 8 ft. internal diameter, the core being of hollow tile, and the exterior of brick and cut stone.
>
> Some extra cost? Yes. But a chimney is unavoidably a conspicuous object. Isn't it worth while, for a few per cent added cost, to make it conspicuous for its beauty?

I wish we could say Amen to this quotation. I fear it will be some time before we can say "So be it" to this principle in water works building design: Nevertheless, the elevated tank and the stack are the two most conspicuous features of most waterworks problems. The buildings usually are relatively low, and are not always conspicuous. Sometimes they are never seen until within a short distance of them, but the stacks and the tanks rear their ugliness to heaven. They can sometimes be seen for miles around.

A third feature frequently found in connection with pumping stations, although more frequently in electric power plants, is the bank of transformers. These are not beautiful. No attempt is made to make them so. Still they are commonly found, apparently literally stuck around almost anywhere that is convenient. They

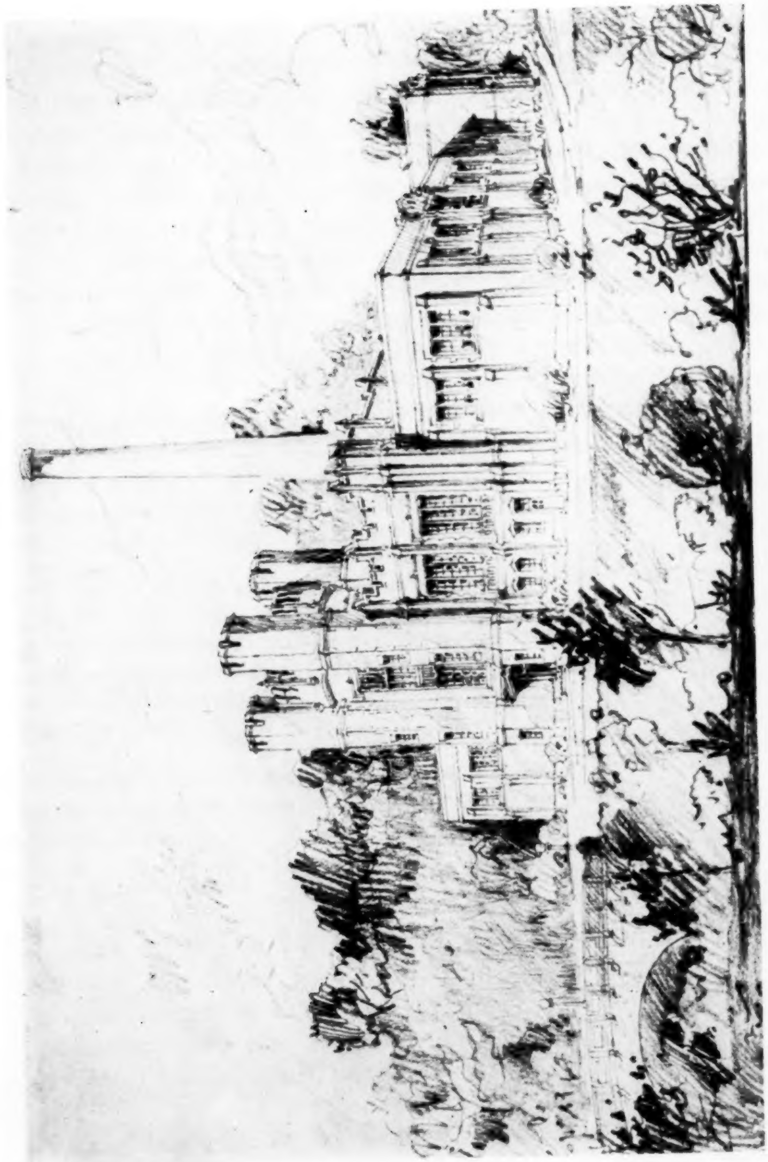


Fig. 5. Sketch A. Knoxville Pumping Station and Filter Plant

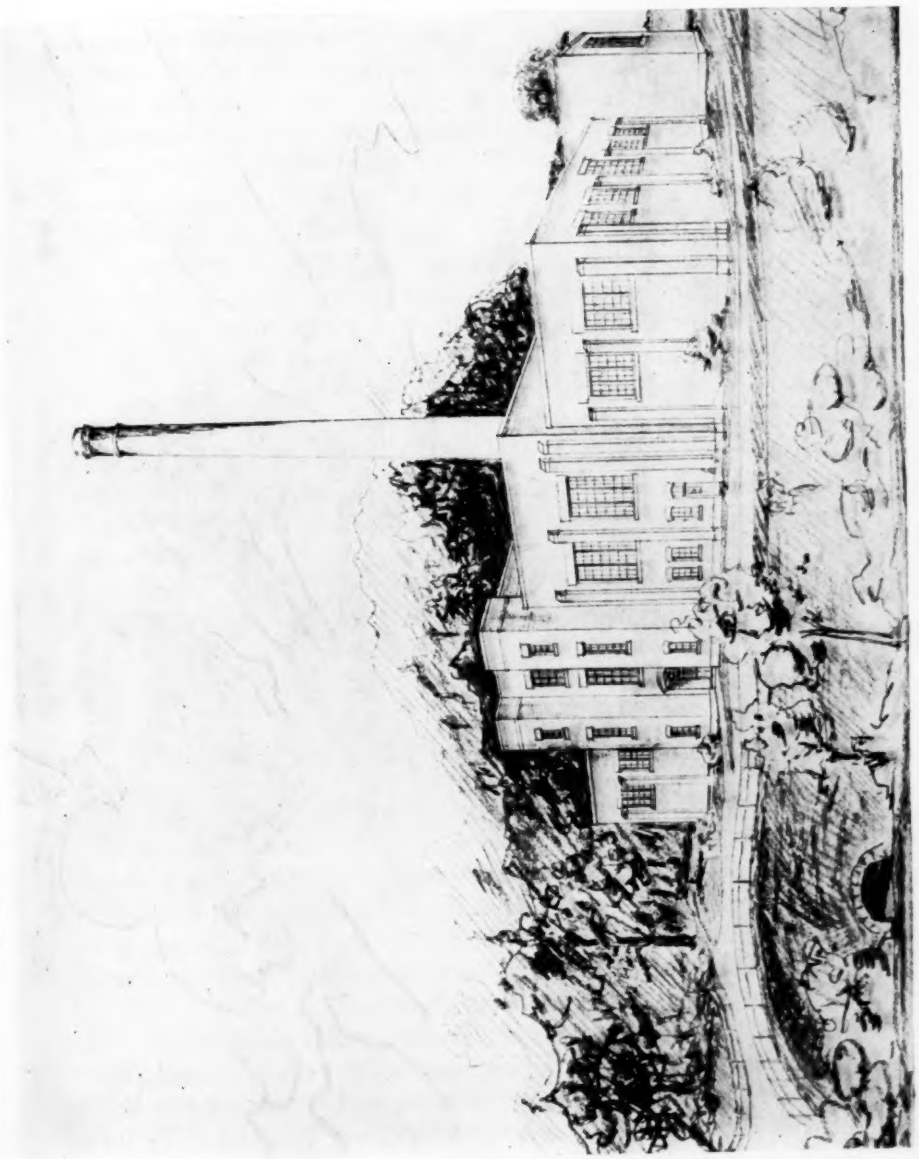


FIG. 6. SKETCH B. KNOXVILLE PUMPING STATION AND FILTER PLANT

are not a difficult problem, if given due consideration when designing the buildings and equipment. It is not very expensive to conceal them. They can be housed in their own building at a distance, with underground low tension wire connections, or in their own section of the main building, or placed in a tower, on the roof, or even in the basement in some cases. The wires can be run in suitable cables underground, usually. There seems to be less excuse for such marring features than in the case of tanks and stacks, due to the comparative small expense of concealing them.

Accepting the chimney as usually constructed, it is sometimes possible for the designer of the building so to treat the building that the chimney is not quite so apparent, even though it may be different from the building in design. The first important thing to do is to see that the chimney is constructed of the same material, or at least the same color of material, as the building. This eliminates the steel stack from all consideration, so far as the subject of good architecture is concerned. If the stack must be of concrete, the building should be of concrete, of the same color, or else of stone of similar color. It is almost impossible to find a grey brick, without a yellow tinge, that will match concrete. If a radial brick stack is used, a brick for the building should be selected that will, when laid, give the same color effect. This is difficult, but at least the color may be made to harmonize.

In figure 5 the building is designed along Gothic lines, and the tower with its turrets, the buttress, pinnacles and other features breaking up the skyline, and giving an emphasis to the vertical lines, tend to take the attention from the chimney, and to render it less conspicuous, and to harmonize the building with its upright lines. In the case illustrated, the location of the building is close to a rather high hill and in a hilly situation. The Gothic style with its emphasis of vertical lines lends itself to this situation better than would a style with the horizontal lines predominating.

This illustration gives opportunity to mention briefly some of the considerations governing the choice of style used in this particular building. It has been pointed out that the location was one of the governing features, and that the effort made to detract from the stack, by the use of vertical lines in the building, was another. There is a third item of importance which applies in any building, but particularly in a pumping station. This consideration is the fact that in these buildings the proportions are largely predetermined. The

designer is necessarily given but little latitude in the length, breadth and height of the various portions of the structure, and these different portions bear a certain relation to each other, governed by engineering considerations not within the control of the designer. In the use of the so-called classic styles, such as Greek, Roman or Renaissance, the proportions are more or less fixed. The width, breadth and height bear a certain proportionate relation to each other, which, if violated, will spoil the effect. Such buildings are usually symmetrical, or at least must be well balanced in design. In the majority of

FIG. 7. AN ATTRACTIVE PUMPING STATION IN RENAISSANCE STYLE IN A CITY PARK

cases it is almost impossible satisfactorily to adapt these requirements to those of the engineering requirements without a sacrifice, either of the most economical and practical plan, from the purely engineering standpoint, or else of the architecture.

Medieval architecture is more flexible in its proportions, and therefore more adaptable to an unsymmetrical problem, in which there are various units of different size and height. This does not necessarily have to be Gothic, but there are several styles of Medieval or Renaissance periods in various countries furnishing architectural types, any of which can be more easily adapted than the classic. These

styles are also sometimes "modernized" and adapted to present day conditions. These modernized Medieval and Renaissance styles would probably not be recognized by the people of the period that furnished the prototype for them. They sometimes may be very interesting, and more often are very uninteresting, if not ugly. They give an excellent opportunity to the unskilled designer to do something "different," and get by with it. These styles furnish the bulk of the modern power house and factory type design. Some of them are said to be "Gothic" or "Renaissance," because they have a few details of those periods, but usually bear no other similarity. The field for originality in these styles is very great, and as it does not require a great amount of knowledge either to design them or to appreciate them, they are quite popular. It does not necessarily follow, and I do not wish to imply, that all of these buildings built in modernized styles are badly designed, or the work of unskilled designers. Some of them are very clever pieces of design, and many are very attractive. This, however, does not apply to the general run of texture brick buildings with white terra cotta or stone ornaments scattered over them. These are sometimes called the "Factory Style." I am not certain whether it is because many factories are built in the style, if such it be, or whether the style was made in a factory, but I suspect the latter. In many cases it would cost no more to secure pleasing lines, better detail, more harmonious color, better fenestration, which means the arrangement of windows, and better balance of the details, without changing the proportions of the walls as regards height, length, and breadth.

In discussing the subject of water works design from the standpoint of the architect, the matter of cost has been avoided. We are not attempting to discuss the subject from an economic point of view, except indirectly. Indirectly, it is economic to give the public beautiful as well as useful things, but I will not attempt to go farther into this subject. We realize that politics also enters into the consideration, but we are avoiding that. In order to secure better conditions in any line, it is necessary to consider what ought to be, the ideal, and then apply it so far as possible to the conditions as they exist.

It may not be out of place, however, to call attention to the two pencil sketches illustrating the same building as shown in figures 5 and 6. The two buildings are identical in every essential *practical* feature. In one, the top of the tower has been omitted. It contains

nothing. The shape of the main tower has been simplified, as the octagonal corner features have been squared. In these drawings the location and height of the walls are otherwise identical. The size and location of all windows and doors are the same in each. The interior treatment was to be the same in each case. Buttresses, which were necessary for the support and bracing of the walls where crane girders and roof trusses occur, have been retained in the simplified design. The design of the parapet and coping has been simplified and consider-

FIG. 8. STURDINESS COMBINED WITH RICHNESS AT PRACTICALLY NO EXTRA COST

able cut stone omitted in the plainer design. I hardly think there will be any difference of opinion as to which is the more attractive. The estimated difference in cost was something less than 10 per cent. It is a matter of gratification to know that those in authority thought the difference in appearance worth the extra cost in this case, and you will therefore never have the painful experience of actually seeing the more economical structure.

Figure 8 shows a building, designed somewhat along the lines of the so-called "Factory Type." It could hardly be simpler, and yet, at

first glance, it seems ornamental. It has a sturdy appearance, which I presume may be considered appropriate in a pumping station. Its ornamentation consists chiefly in the use of two patterns of terra cotta panels located in the pilasters over the buttresses and in the use of ornametal stone caps over these pilasters, which break the skyline. The wall coping has a very simple moulding and projects only slightly. The balance of the stonework is flush. Terra cotta was adopted for the two patterns of ornamental panels referred to, because but two carved patterns had to be made, and the rest is cast from them. If

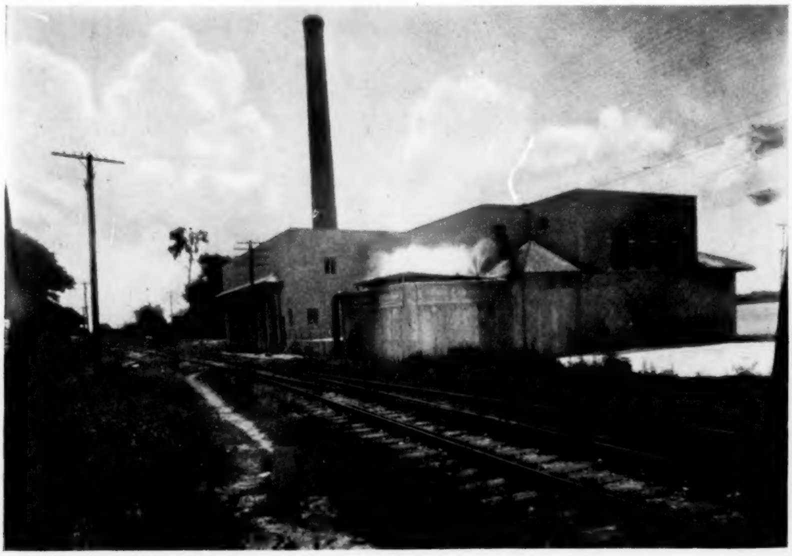


FIG. 9. A FILTRATION AND PUMPING PLANT IN FLORIDA

these were of stone, each one of the panels would have had to be carved and the cost would have been much greater. The panels are of the same color and surface finish to match the stone. The principal buttresses are needed to reinforce and brace the wall where the roof trusses and crane girders bear. The group of similar buttresses at the corner of the building and of the vestibule are there merely for effect. The entire character and the effect of sturdiness of the buildings is gained by means of these buttresses and pilasters and on their use at the corners. The pilasters in themselves added nothing to the cost of the building. It was necessary to provide interior crane girder supports. Due to the height of the wall, it would have been necessary

to have increased its thickness had the exterior pilasters been omitted. The increased thickness of the entire wall and foundations would have been slightly more costly than the buttresses. The cost of ornamentation then must be charged almost entirely to the 22 terra cotta panels, and an equal number of stone buttress caps. The coping would have been necessary in any case, and the small amount of stone otherwise used is less than in the average plain building. The base is of concrete. The panels in the upper part are formed by a recessed course of brick, and by setting the brick on end in white mortar, while the back of the rest of the building is laid in brown mortar. The brick is of a brownish mixture, with a rough surface.

Fig. 10. Rustic Antique Spanish Effect, by Use of Cochina Stone, in a Florida Water Plant

While no figures are conveniently available, I doubt if the difference in cost between this building and a similar one of the utmost plainness, would amount to more than 0.5 per cent of the total cost.

The design of any building is influenced not only by its immediate surroundings, but by the climate. In northern countries the natural requirements of the climate developed steep roofs to shed snow. In southern climates flat roofs are customary. In the south, due to climate and historical association, buildings of the Spanish or Italian type, or developed from the Indian architecture such as that of the Pueblo Indians, are popular, and has much of merit to commend it artistically. This architecture adapts itself easily to the require-

ments of the class of buildings under consideration. The building illustrated in figure 9 is of white stucco on brick and concrete, and the visible roofs are of Spanish tile, and the copings of the walls surrounding the flat roofs are of the same tile. The chimney, much in evidence in this case, is of red radial brick, unfortunately. This is an instance where a concrete stack would have been more in harmony with the building.

An interesting feature is the open boiler room, protected against the weather by a projecting canopy but with no glass or sash. The openings are protected by ornamental grilles, which were not in place when the picture was made. The openings are of sufficient size to permit the removal of boiler tubes, and in fact to unload machinery from the tracks immediately back of the building. No coal bins are provided, as oil is used for fuel, and the tanks are filled directly from tank cars.

An interesting detail showing the stonework of some of the arches and the simple wrought iron railing and tile roof of another Florida plant is illustrated in figure 10. The floors are all of bright red tile, and harmonize nicely with the stone, yet give a pleasing contrast.

So far consideration has been confined to the exterior of the water works.

Of the interior, there is less to be said. Of the total number of persons who see a water works chimney or tank, few see the building, and still fewer go inside. For this reason it may be argued that there is less reason for attempting to make it attractive. There are, however, some principles of beauty that should be applied to the interiors, without greatly increased cost and without much attempt at ornamentation. Simplicity is one of these. Cleanliness, pleasing proportions and sturdiness are others. In a pump room, the pumping machinery is the principal article of furniture. The room can be made attractive and still be in harmony with the color and general character of the machinery. It can be made to give the impression that the pumps belong there.

To illustrate: A pumping engine would not look well in a room designed and decorated for a bedroom, if it were large enough to hold it, although it might be a very beautifully designed room. Neither would a pump look well in a church. Not because we are not used to seeing pumping engines in bedrooms and churches. That is really not the point. Certain features, proper and consistent, in the design of these two classes of room are out of harmony with the character of

a pump. One of the characteristics of a pump is that it is a piece of machinery. Another is that it is heavy and bulky. There are many others, all of which have to be consciously or unconsciously considered in designing a pump room. The necessity of being fireproof, automatically removes the objection to woodwork. It is one of the features out of harmony with the material of pumps.

In general, it may be said that the interior of a pump room should be simple, without being barn-like or bald. The materials should be well finished, as they are in good machinery. They should be of a material that is permanent and sanitary, and easily kept clean. They should be of a color that will look clean, even if slightly soiled. Pure white is not an entirely satisfactory color for it takes little to soil it. On the other hand, it is a mistake to use dark colors, merely because they will not show the dirt. A pump room should be light, and, of course, well ventilated to make it an inviting place. Pumps in pits are hard to light and ventilate, and of all kinds of pump rooms, the one in a pit is the one that should receive the most care in its design or it will be nothing but a crowded hole with a wet floor—a most uninviting looking place.

In selecting the material for any building, it is a mistake to appoint a committee to do the selecting, or to have this done by the building committee, or officials of the water department. The person who designs the building is the one who should determine the materials to be used. Their color, texture, quality, and all of their characteristics are closely involved in the success of the design. An otherwise well designed building can be ruined by its color, or by an unharmonious combination of colors. Color in itself is a purely relative matter. There is no such thing as a beautiful or an ugly color *per se*. They become beautiful or the reverse as judged in comparison with the surrounding colors. It is true that brilliant primary colors are to avoided always unless used in minute quantity, secondary colors are difficult to handle, so that the choice is nearly always one of tertiary colors. So the responsibility for the color and texture of the materials should be left with the designer, as well as the matter of their shape, all being of equal importance. It should be assumed that the designer is a specialist in these matters, while the layman is an amateur. If the amateur in any given case happens to be one of unusual attainments in this particular line, the specialist will usually be glad of his advice and assistance.

From what has been said it might easily be inferred that the ar-

chitects viewpoint is confined to what is called appearances—good or bad. This is not the case. As has been mentioned, there are several considerations involved in the proper design of a building, of which three are of prime importance, namely: construction, arrangement, appearance. The architect is very much concerned with all three, and even if he should be chiefly interested in the appearance, it is necessary to give construction and arrangement consideration before the question of looks can be intelligently considered. Construction involves the proper use of materials, their color, texture, strength, and general appropriateness for the use to which they are to be put. It also involves the strength and durability of the structure, both of which are components of looks. It is almost unnecessary to point out the necessity for a good plan. It is an axiom among designers that first consideration should be given to the plan, or scheme, without which a satisfactory result is impossible. A good plan involves systematic arrangement with a certain end, or aim, in view. It involves the location of the various units with reference to each other in such manner as to afford proper functioning with the least lost motion and waste of space, operation with the least amount of labor, combined with ease of access and communication, and some consideration in many cases to the question of expansion. In order to produce such a plan, coöperation is required between those familiar with the construction, operation, maintenance and functioning of the various units, and those familiar with the grouping of such units in a well balanced plan involving the features before mentioned. Such a plan, arrived at after intelligent consideration of all such features by those used to this specialized kind of work will naturally result in a good plan, on which can be developed a building whose exterior and interior may be pleasing. No set rules for the production of such a plan are possible. Satisfactory results from a so called "architectural" point of view as well as a so-called "practical" point of view, can be obtained only by the coöperative effort of those who are trained in all of the various special lines involved. I have referred to the term, *so-called practical* and architectural points of view, but as a matter of fact there should be no distinction. In a properly considered design there would be no distinction, as a proper architectural point of view is a practical one. It runs counter in no way to good engineering, but, like engineering, involves an adjustment of the various requirements to each other in such manner that the whole, rather than an individual feature, may be as perfect as possible.

A STUDY OF CURRENTS IN LAKE ERIE AT ERIE, PA.[1]

By D. E. Davis[2]

In view of the extensive use of the Great Lakes, both as sources of water supply and also as means of sewage disposal for numerous communities, the relationships between the possible contamination from the sewage and its effect upon the water supply are of prime importance. Many contributions have been made to this problem in the studies pursued in several lake cities, and a comprehensive picture of lake pollution is presented in the report of the Commission on Pollution of Boundary Waters. This paper will describe that phase of a study at Erie, Pa., which has to do with the effect of winds and lake currents on the probable distribution of polluted water.

The City of Erie possesses a fine land-locked habor known as Presque Isle Bay which is formed by a peninsula meeting the mainland at a distance of approximately 5 miles between extremities and enclosing a body of water over 6 square miles in area, entrance to which is gained through a dredged channel maintained by the Government. The principal portion of the city is built along and back of this bay front. Until recently the greater part of the city's sewage entered the bay through a number of outlets which now, however, are largely connected into intercepting sewers whose terminus will be at the lower end of the bay near the inlet. Since no treatment has been given this sewage, the conditions about the outlets have not been ideal, and the State Health Department has been anxious for the city to give consideration to other means of disposal, and to that end ordered an investigation made.

One of the possible disposal arrangements looked to the carrying of the sewage, after more or less preliminary treatment, into the lake proper through a submerged conduit terminating something over a mile below the inlet to the bay. The principal interests which might be affected by this future discharge are represented by the

[1] Presented before the Buffalo Convention, June 9, 1926.

[2] The J. N. Chester Engineers, Pittsburgh, Pa.

waterworks intake located near the upper end of the peninsula in the lake proper and about 5 miles west of the proposed sewage outlet; the bathing beaches along the shores; and the intake of a large paper company situated just below the present bay inlet.

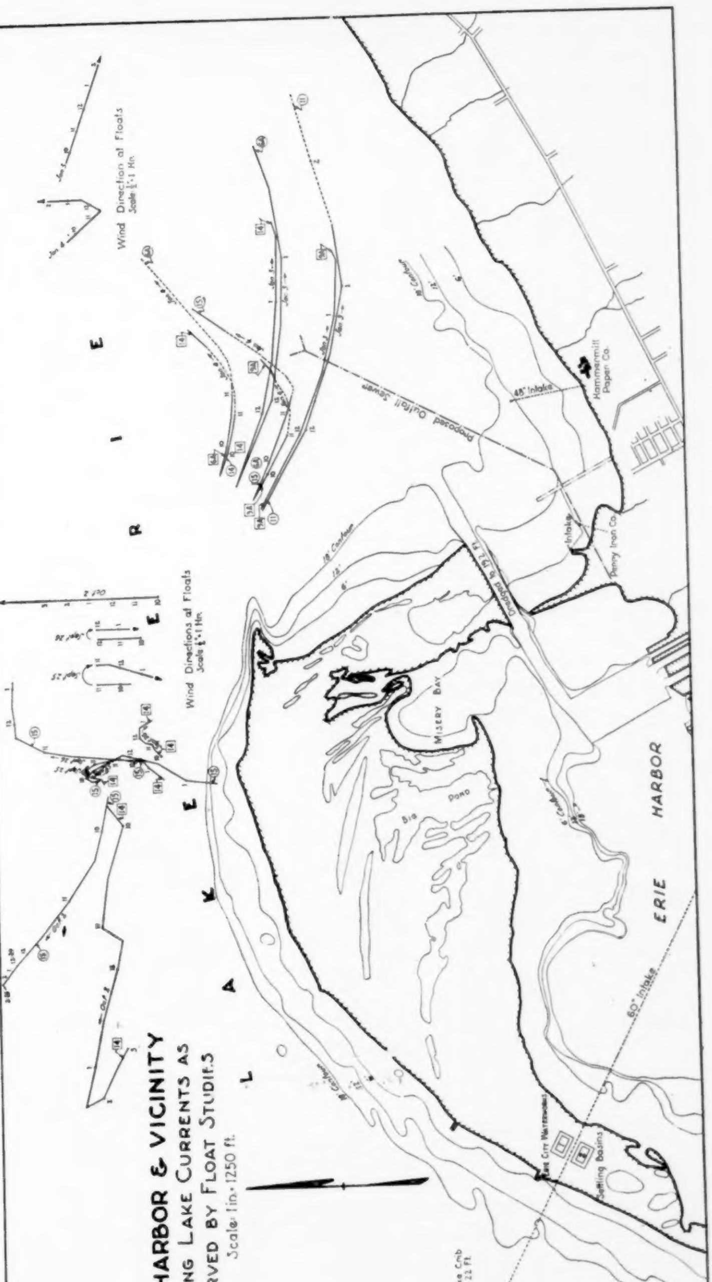
Since, in the nature of the case, no sewage is now being discharged at concentrated outlets in the lake, it has been necessary to approach the problem in an indirect manner, and to pursue such studies as would throw light on what the future might hold under the new conditions. The investigation has developed into a search for present evidence from which future prophesies might be made. Among the various methods of attack available, those which were singled out as offering the greatest promise of helpfulness, were:

1. The effects of lake currents studied through the movement of surface and sub-surface floats.
2. Chemical and bacteriological analyses and comparisons.
3. Temperature studies.

This paper will be largely confined to the results of the float studies.

It has been recognized for some time that among the various agencies causing lake movements, the winds have by far the greatest influence. Because of the immense size of the lakes, the normal flow down lake is very slow; currents from surface streams do not affect this immediate problem; and barometric effects will hardly be noticeable within the time periods considered. The distribution of pollution will therefore be largely determined by the action of the winds, as modified by local topographic conditions, hence the importance of their study in this instance.

The floats finally adopted as proving most useful consisted of a 1 inch by 3 inch vertical stick properly weighted, to whose faces boards were nailed, forming vanes which presented a maximum of surface exposed to the water and a minimum to the wind. The flags were triangular in form, 18 inches at the base, by 26 inches long, divided into two colors along the horizontal axis. The sub-surface floats were similarly made up, the lower element being attached to the upper float by sash chain, wire and fish cord being found unreliable. The floats had the merit of being light in weight and therefore easily handled. These floats were released from a steam tug, made available by the State Fish Commission, which was capable of navigating under all weather conditions, including some pretty choppy water. A base line about a mile and a half in length had



ERIE HARBOR & VICINITY
Showing Lake Currents as
Observed by Float Studies
Scale: 1 in. = 1250 ft.

TABLE 1

Tabulation of direction of float movements for various wind velocities and corresponding current velocities, north point is taken as 0°00′ and directions are shown in division of 20°, velocities in miles per hour

DIRECTION OF FLOAT MOVEMENT	VELOCITY		PER CENT CURRENT TO WIND
	Wind	Current	
0–20°	20	0.44	2.2
	22	0.32	1.5
	23.5	0.39	1.7
	18.2	0.20	1.1
	19.3	0.21	1.1
	15.2	0.15	1.0
	15.2	0.16	1.1
Average			1.4
20–40°	12.2	0.20	1.6
	12	0.16	1.3
	6.5	0.08	1.2
	13.2	0.11	0.8
	23	0.20	0.9
	23	0.23	1.0
	10	0.26	2.6
	9.6	0.135	1.4
	18.2	0.20	1.1
	19.3	0.16	0.8
	6.5	0.15	2.3
Average			1.4–
40–60°	6.5	0.13	2.0
	6.5	0.13	2.0
	12.3	0.125	1.0
	17	0.17	1.0
	17	0.17	1.0
	10	0.28	2.8
Average			1.6
60–80°	12	0.39	3.2
	8	0.24	3.0
	16	0.38	2.4
	13	0.38	3.1
	13	0.39	3.2
	14	0.28	2.0
	12	0.37	3.1
	15.7	0.44	2.8
	22.5	0.72	3.2
	21	0.67	3.2
Average			2.9
80–100°	16	0.49	3.1
	17	0.53	3.1
	8	0.31	3.9
	15	0.38	2.5
	10.3	0.36	3.5
	10.5	0.37	3.5
	9	0.29	3.2
	15.7	0.51	3.2
	6.2	0.15	2.4
	6.2	0.14	2.3
	8.7	0.17	2.0
	7	0.12	1.7
	15.7	0.43	2.7
	15	0.44	2.9
	13	0.35	2.7
	22.5	0.72	3.2
Average			2.9
100–120°	19.3	0.37	1.9
	6.5	0.25	3.8
	10	0.28	2.8
	9.5	0.17	1.8
	12.3	0.32	3.0
	14.5	0.33	2.3
	14.5	0.46	3.2
	12	0.24	2.0
	15.4	0.48	3.1
	7	0.18	2.6
	12.3	0.27	2.2
Average			2.6
120–140°	17.5	0.59	3.3
	14	0.31	2.2
	5	0.11	2.2
	11	0.19	1.7
	15	0.37	2.5
	14	0.27	1.9
	15	0.35	2.3
	5	0.16	3.2
Average			2.4

TABLE 1—*Continued*

DIRECTION OF FLOAT MOVEMENT	VELOCITY		PER CENT CURRENT TO WIND
	Wind	Current	
140–160°	10	0.28	2.8
	10	0.25	2.5
	11	0.22	2.0
Average			2.4
160–180°	19	0.48	2.5
	19	0.22	1.2
	10.4	0.15	1.4
Average			1.7
180–200°	10.4	0.16	1.5
	7.3	0.095	1.3
	7.3	0.085	1.2
Average			1.3
200–220°	10.7	0.12	1.1
	6.2	0.06	1.0
Average			1.1
220–240°	10.7	0.14	1.3
	6	0.06	1.0
Average			1.1
240–260°	15	0.27	1.8
	7.5	0.24	3.2
	7.5	0.24	3.2
	15	0.24	1.6
	15	0.29	1.9
	7	0.25	3.6
	7	0.23	3.3
Average			2.6

DIRECTION OF FLOAT MOVEMENT	VELOCITY		PER CENT CURRENT TO WIND
	Wind	Current	
260–280°	14	0.28	2.0
	12.5	0.31	2.5
	16	0.27	1.7
	8	0.24	3.0
Average			2.3
280–300°	16	0.25	1.6
300–320°	16.5	0.31	1.9
	17	0.29	1.7
	5	0.13	2.6
	16.4	0.20	1.2
	16.5	0.28	1.7
	15.7	0.25	1.6
Average			1.8
320–340°	13.6	0.29	2.1
	11.1	0.31	2.8
	13	0.34	2.6
	20	0.26	1.3
	14.3	0.21	1.5
	22	0.48	2.2
	21	0.51	2.4
	14	0.18	1.3
	15	0.29	1.9
Average			2.0
340–360°	8.6	0.23	2.7
	20	0.33	1.7
	12	0.18	1.6
	19	0.29	0.5
	15	0.25	1.7
	11	0.37	3.3
Average			2.1

been established along shore, one end on a high bluff and the other on the top of a 60-foot abandoned light house so that the movement of the floats could be readily observed for long distances. Observations were made simultaneously at 15-minute intervals for float

location by means of angles from the base line. The approximate wind directions and characteristics at the floats were also noted. Observations were made from the latter part of October 1923 through the early part of January 1924 (when the lake froze over) and again for a few days in August and September 1924.

In all, the records of forty-seven days embracing 160 float releases were studied. During the progress of this study a wide variety

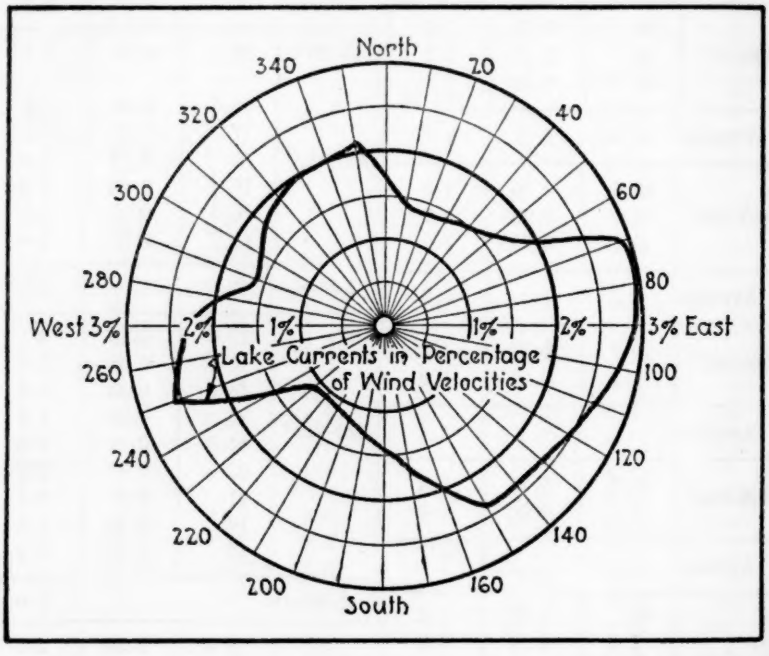


Fig. 2. Average Percentage Relationships Between Wind and Current Velocities for Various Directions of Float Movements

of weather conditions prevailed: velocities from mere breezes to those over 30 miles an hour were observed; winds from various directions of the compass were encountered; and in one case we had the extreme good fortune of observing the effects of a "seiche" wave.

It is believed that sufficient evidence has been collected to establish that the results are representative of practically all conditions to be expected.

The observations were plotted on standard maps (see figure 1)

and from the resulting curves, the velocity and direction of the current could be readily determined. In the analysis of the results an effort was made to discover whether or not there was any correlation between the wind velocities and directions and the corresponding currents in the lake water. To this end tabulations of these features were made covering each sustained wind movement and then this relationship was plotted. These curves demonstrated that winds from some directions appeared to exert greater tractive effort on the water than did others, and, from this hint, another tabulation was made on the basis of arbitrarily dividing the 360 degrees of the circle into 20 degree units and throwing the corre-

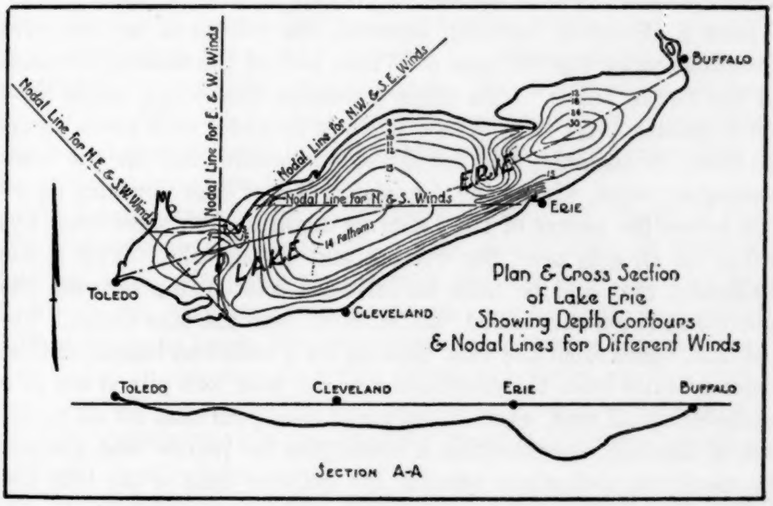


FIG. 3

sponding observations into these catagories regardless of the time when observations were made.

These results may be found in table 1 and the graphic record on figure 2. The peculiarly symmetrical character of the curve will at once be remarked, and as this result could hardly be attributed to chance, some explanation of the reasons occasioning it will be sought.

The contour map of Lake Erie, figure 3, reveals a relatively deep portion (about 34 fathoms) between Erie and Buffalo, while in the in the opposite direction towards Toledo the lake is comparatively

flat and shallow (14 fathoms). The connection between these two portions is through a narrowed neck extending between Presque Isle Peninsula and the Canadian shore. The cross-sectional area at this connecting neck is about half that of the mid-lake sections on either side.

It becomes evident that when there is a tendency for delivery of water between the shallow and deep body of water, the velocity through this narrowed channel (called the Canal by the Erie fishing interests) will be greatly increased over that existing at mid-lake. That such movements of water through this Channel actually occur can be demonstrated both by our observations and by theoretical considerations. The latter will be considered at this point.

John F. Hayford, in 1922, reported the results of an extensive investigation of the "Effects of Winds and of Barometric Pressure on the Great Lakes." He there concludes that some winds have much greater effect than others in piling up water on a given shore. He finds, for instance, that for direct east winds (and for the complementary west winds) the transfer of water does not turn on an axis across the center of the Lake, as might at first seem true, but rather on an axis near the western end of the lake. This is the shallowest part and he finds an intimate relationship between the position of these axes called "nodal lines," and the lake depth. For instance, winds from the east blowing for a sufficient length of time displace water from the eastern end of the lake and pile it up in a relatively small area, west of this nodal line, such that for all points east of this line, the elevation is lower than for points west thereof, the maximum deflections being at the extreme ends of the lake and the line of no change of elevation being, of course, the nodal line itself. Nodal lines for the quarter points of the compass are shown in figure 3.

On page 53 of his monograph, he produces a table of values for a factor used in a formula from which may be deduced the effect of winds from various directions in the raising or lowering of the lake elevation at given locations. Figures for Cleveland and Buffalo are shown and we have made an estimate of the factors which might apply at Erie by interpolation between the results for these two cities. They are as follows and represent the probable relative effects of various winds.

Relative effects of winds in raising or lowering lake elevation in relation to mean lake elevation

DIRECTION OF WIND	AT BUFFALO	AT CLEVELAND	AT ERIE
NE	−8.32	−3.89	−6.2
E	−5.90	−2.86	−4.4
SE	−2.26	−1.90	−2.1
S	+3.45	−1.72	+0.9
SW	+8.32	+3.89	+6.2
W	+5.90	+2.86	+4.4
NW	+2.26	+1.90	+2.1
N	−3.45	+1.72	−0.9

From this it will be seen that north and south winds have relatively little effect upon Lake elevations at Erie, and southeast and northwest winds only a little greater effect. The winds which are most effective in changing the lake elevations are northeast or southwest winds and east or west winds. Observations of bay elevations at Erie corroborate these expectations.

The longitudinal axis of Lake Erie lies about 30° North of East, and it is evident that winds 45° on each side of east (or west) will tend to drive water directly through the narrowed neck at Erie. However, for northerly (and southerly) winds there is a sudden shift of the nodal line to the center of the lake, passing almost through Erie Bay. In this case the water slopes, as between the two ends of the lake, will be materially reduced below those for easterly (and westerly) winds, and the tendency for transfer of water through the neck will be at a minimum.

These deductions furnish a background against which the results of the Erie float observations may be viewed. Figure 2 pictures conditions where easterly (and westerly) winds consistently effect greater corresponding current movements than do northerly (and southerly) winds. From a rational standpoint there is reason to believe that, say out in the middle of the lake, winds from any direction would have a like proportional effect on currents, under similar conditions. If this is true, it follows that if higher velocities are observed, they must be the result of added increments of force. At Erie such increments appear to be present in the increased velocities through the narrowed neck.

The tentative explanation of the observed results runs in the following terms: Any wind tends to (and within close limits does)

set up a lake current in the same direction, whose velocity will be roughly directly proportional to that of the wind. For conditions at Erie, it is believed that the northerly (and southerly) winds fix this normal current velocity at something over 1 per cent of the corresponding wind velocity. Easterly (and westerly) winds, however, have an added component of velocity contributed by the speeding up of the lake waters through the narrowed neck above Erie's peninsula. The float movement will then be the resultant, both in direction and velocity, of the forces acting upon it. Easterly (and westerly) winds (including 45° on each side of E. and W.), may be expected to be deflected towards east (or west), and to acquire an increased velocity, above normal. The observations disclose exactly this situation. Winds from the westerly quarters seem to produce currents which are roughly $2\frac{1}{2}$ per cent of their velocity, while those from the easterly quadrant average something over 2 per cent; that is, these winds develop roughly twice the current velocities that northerly (or southerly) winds do. The "increment of velocity" will doubtless be affected by many things, including the angle of the wind, the position of previous winds, duration and constancy of the "blow," and consequently considerable variations from the average may be expected, but the number and consistent character of the average results leaves little doubt that considerable reliance may be placed in the findings for this particular location.

Many interesting "by-products" grew out of the investigation, which need be only briefly mentioned. Sub-surface floats (up to 25 feet below surface) acted invariably in a similar manner to surface floats. The velocities, however, were lower (averaging about 85 per cent of the surface floats), and there was often a deviation in direction, evidently because of the influence of previous winds. Sudden wind changes sometimes "boxed in" the sub-surface currents compelling "hair-pin" turns. No reverse or "under-tow" currents were observed, thus confirming Whipple's observations at Cleveland, and being opposite in character from his Rochester observations.

It remains to discuss another observation which is of the first importance in the possible transportation of pollution.

On October 2, 1924 (plotted on figure 1), a phenomenon was observed which turned all our previous conclusions "topsy-turvy." An inspection of figure 1 will disclose that the direction of the float move-

ment was definitely towards the west or up-lake towards Toledo (although the winds were from the south); and a peculiar characteristic of this observation is that the sub-surface float (25 feet below the surface) moved at a faster rate than the surface current. The observers reported a distinct "swell" running *down lake* or in a direction opposite to the float movements, while the wind direction was from the south and southwest and averaged approximately 13 miles per hour.

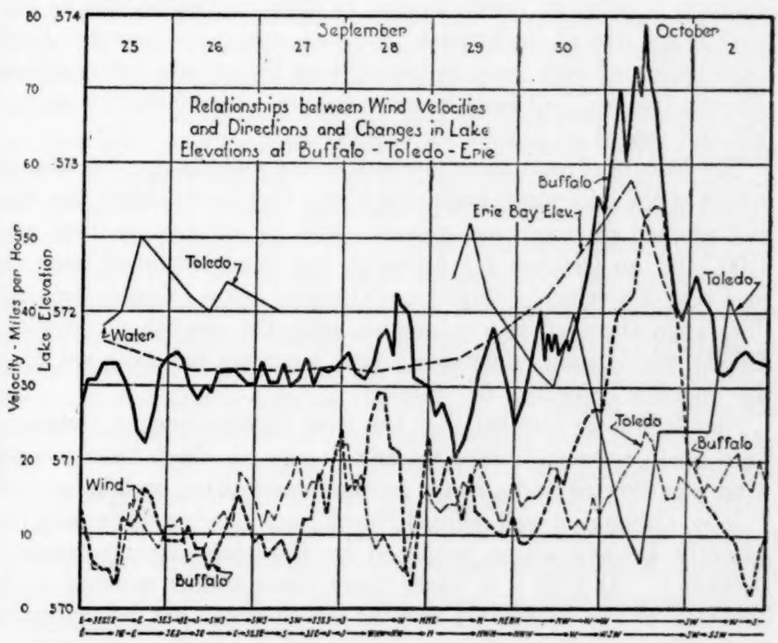


FIG. 4

In search of an adequate explanation for this wholly contradictory observation, recourse was had to wind direction and velocity records as well as lake elevation data at Toledo, Erie, and Buffalo. These records are graphically depicted on figure 4.

It will be seen that a northwest wind began to blow at Buffalo a little after noon on September 30 (and at about 4 o'clock a.m. at Erie), and continued to blow from a westerly direction until about 6:00 p.m. October 2. Similar conditions were noted at Toledo although the velocity of the wind was not as great, reaching about 24 miles per hour at its maximum at Toledo, and about 55 miles at Buffalo.

The water level at Buffalo began to rise simultaneously with the rise in the wind, but reached its maximum about four hours before the wind was blowing its hardest, and then began to drop precipitately and continued to drop, although the wind remained in the west, but at a lower velocity, until about 6 o'clock p.m., October 2. This also marked the lowest point in the lake level reported at Buffalo during the whole time of observation, since from that time forward a rise was noted. During this same period, however, a reverse situation is noted at Toledo so that at about the same time as Buffalo's stage was at its highest, Toledo's was at its lowest. Erie's stage (recorded only once in twenty-four hours) was intermediate, between the two, but had the same general characteristics as Buffalo and was at its highest on October 1.

The feature of particular moment is the sudden drop in the elevation of the lake water beginning about four hours before the wind had reached its maximum velocity, and its continuous drop until 6:00 p.m. on October 2. Although the wind remained from the west and at a velocity which never dropped below 32 miles per hour, this, when observed in conjunction with the records at Erie and Toledo, would show conclusively that a current had been set up in the opposite direction, or up-lake.

Now it will be recalled that the float observations on October 2 were made between 9:30 a.m. and 3 p.m. at which time a south wind was blowing and a heavy current was moving up-lake towards Toledo, although a well defined "swell" was moving down lake (apparently a wave action produced by the high velocity winds of October 1. At 1:30 p.m. sharp there was a sudden reversal in the direction of the subsurface current which could not be accounted for by the immediate effect of the wind then blowing. An explanation may be sought in the recorded data on figure 4 where it will be seen that the highest elevation of the lake at Toledo was reached at about 11:00 a.m. on October 2, whereas the low at Buffalo was not reached until about 6:00 p.m. on the same date; in other words, it took nearly seven hours for the seiche wave which began to travel down lake from Toledo at about 11 p.m. to make itself felt in the reversal of current at Buffalo and the consequent rise in the lake Level at that point occasioned by the transfer of water to Buffalo. Undoubtedly this "travel wave," causing a reversal in current direction, would make its appearance at Erie before it would at Buffalo and from these records it appears that this reversal was noted at

Erie about two and one-half hours after the high level condition at Toledo, which is not an unreasonable expectation.

These observations seem to lend considerable color to the validity of the foregoing explanation and to point to a reverse current being set up through the action of prolonged westerly winds of high velocity, and in all probability a similar action for winds in the opposite direction.

These "seiche" waves have been recognized before, but so far as it is known no direct float movements have ever been observed which throw on their velocity and habits. Two studies of water fluctuations on the great lakes have been made in the past, one by Professor Alfred J. Henry, "Wind Velocity and Fluctuations of Water Level of Lake Erie" and by John F. Hayford, "Effects of Winds and Barometric Pressures on the Great Lakes." In both cases "seiches" are definitely recognized and some of their characteristics are discussed. The phenomena of the "seiche" was first observed on Lake Geneva and may be defined as an oscillation in the waters of the lake under the influence of inertia, and not produced by fluctuations in the water supply of the lake. A free oscillation is set up in the lake in the form of a wave motion which involves a transfer of water from one end of the lake to the other. The initial impulses are usually occasioned by very high winds which tend to pile up the water on the shore towards which the winds are blowing until the weight of gravity is sufficient to set up a current along the bottom of the lake in a reserve direction, at which time there will be noted on this shore a relatively quick drop in the lake elevation, although the wind may continue in the same direction, that is on-shore, for a considerable period thereafter.

Mr. Hayford recognizes a seiche for the entire longitudinal length of the lake whose period of oscillation is approximately 13.1 hours (Henry fourteen hours) from peak to peak of wave. Hayford also recognizes a shorter seiche from Buffalo to Erie, (in the deep portion of the Lake) whose period is 3.7 hours. There appears to be a cross lake seiche of about 2.6 hours between Cleveland and the Canadian shore. (Note the peculiar jerky "kicks" to the south of the surface float on October 2, possibly occasioned by a "seiche" running north and south.)

Seiches of large amplitude occur only during high winds, seldom in summer and usually in the fall and winter.

From these observations it may be concluded that seiche waves

actually did occur; that the float phenomena of October 2 are explained in terms of such a seiche wave which was moving up-lake and whose influence was stronger than that of the wind at that time blowing; that it resulted in an actual movement of water up-lake; that the sub-surface currents traveled faster than the surface currents and were less affected by the wind blowing at that time.

The foregoing discussion of seiches and their effects will help to clarify some of the baffling and contradictory observations of the floats released on October 2 as shown on figure 1.

The probable explanation of the conditions of October 2 runs in the following terms. The high winds of October 1 piled up the water on the Buffalo shore as is shown by the observations on figure 4. Without much doubt the quick drop in the lake elevation a little prior to the maximum wind velocity points to an undertow current set up on the bottom of the lake from Buffalo towards Toledo in the deeper portion of the lake. It is quite probable that the upper current continued to travel with the wind towards Buffalo and that on reaching Buffalo it "turned under" and followed as a counter current towards Erie, where it was confronted with the narrowed neck in the lake between the deep and shallow portions. Evidently the forces residing in the undertow or counter-current were of greater magnitude on October 2 than were the surface tendencies at that time, so that as a consequence the sub-surface currents traveled faster than the surface currents.

This is a condition which a consideration of the theory would seem to sanction, for the counter or undertow current is apparently very largely the result of the action of gravity and it may be expected that the portion of the water to first feel the effects will be the deeper lying water.

The observed currents will be the effect of the resultant forces at the narrowed channel. It is entirely probable that the volume of converging undercurrent water will force itself upward and tend to slow up the upper current (which in the beginning was probably flowing with the wind in the opposite direction) and at the end of the period will carry the surface current along with it but at a reduced velocity.

On October 2 the wind had changed from West to South, and, although the seiche current up lake was pronounced, this South wind did tend to deflect the surface current somewhat towards the north so that the resultant flow was slightly northwest. The effect

on the sub-surface current was less noticeable, although the trend can there be followed as well. A sudden shift in the direction of the sub-surface current at 1:30 p.m., at which time it began to practically reverse its direction (corroborated by the slowing up of the surface current during the same interval), probably indicates a reversal of this seiche wave in the opposite direction as might be expected as an inherent condition of such a wave. It will be noted that there was no change in the wind which would account for this current reversal, since the wind continued for sometime from the southwest. As before, this reversal apparently acted on the deeper lying water first and again the sub-surface current demonstrated the action sooner in time and by an increased velocity as compared with the surface.

A study of the meteorological data brings forth the fact that the trend of the winds is, of course, towards the east; in other words, that the prevailing westerly winds predominate. Furthermore that the Easterly and Northeasterly winds occur relatively seldom and so far as observed they have had relatively little effect in setting up seiches. Practically all seiches are the result of Westerly or Southwesterly winds.

It is believed that the foregoing developed results furnish a fairly reliable basis from which to project the probable effects of winds, both past and future, in producing lake currents; and in presenting a picture of the travel habits and characteristics of these currents, and their influence in the possible dissemination of contamination. Since currents arise largely from the sport of the winds and since the direction of the winds cannot be predicted, it was realized that only by observations covering probably a long period of time and by a rare chance would the proper set of circumstances arise for observing the movement of floats around to the water works intake.

This suggested a search for some means whereby the past records of the Weather Bureau might be made to reveal examples of such wind combinations. Although the Weather Bureau records give hourly directions and velocities for eight directions of the compass, their plotting over an extended period would be an endless task, and if the Bureau's summarized daily record of "prevailing" wind and average velocity could be employed for this study the problem would be greatly simplified and the study shortened. A number of hourly plottings were made and their resultant direction compared to the daily "prevailing" direction. It was found that the latter

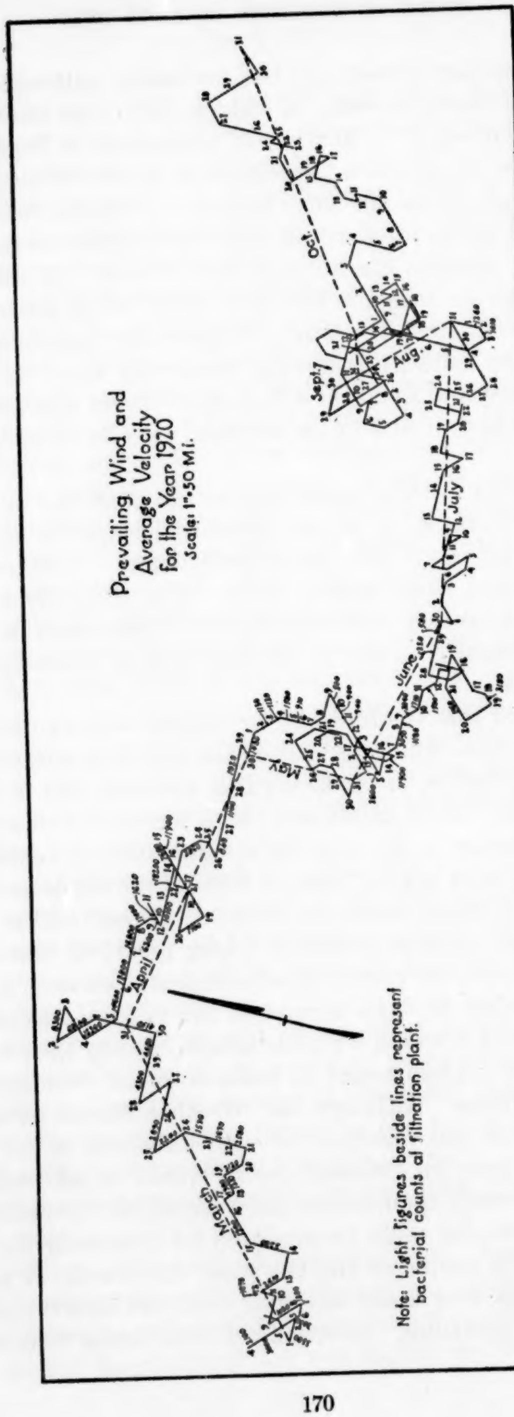

Prevailing Wind and
Average Velocity
for the Year 1920
Scale: 1"=50 Mi.
Note: Light figures beside lines represent
bacterial counts at filtration plant.
March
April
May
June
July
Aug.
Sept.
Oct.

FIG. 5

could be relied upon for picking off the days when the winds might be in the right direction for carrying the bay contamination towards the water works intake. One such plotting for the year 1920 from March 1 to November 1 (the period recorded by the Bureau) is reproduced on figure 5. When the daily plottings pointed to the possibilities of movements towards the intake these days were likewise plotted on an hourly basis and the continuous course of probable travel thereby determined. The occurrence of "seiche" waves were revealed by the plottings of lake elevations at Buffalo, where the combination of high westerly winds with "saw-tooth" dips in the graphs gave evidence of "seiche" movements.

The best aid in checking the evidence of probable contamination was in terms of bacteriological results and to this end the past records of the Water Department yielded data which, when plotted, on the graphs, and also tabulated against wind directions, change in Bay elevations, turbidities, B. coli indices, etc., threw considerable light on the probable number of occasions when contamination reached the intake, and the combination of circumstances which brought this about.

In addition to the foregoing studies, a bacteriological and chemical and temperature investigation was conducted on samples from the lake on a "checkerboard," extending four miles off shore and 15 miles along shore; on a "checkerboard" within the Bay and on one in a concentrated area immediately below the Bay inlet. The past bacteriological data at the Water Plant were studied in detail, and these results checked against the experience of other lake communities with the purpose of learning the probable degree of contamination now existing, its probable growth with increasing population, and the probable degree and extent of contamination which might be expected at the water works intake. Curves were developed setting forth a tentative measure of the relationship between population growth and contamination. The discussion of this phase of the study is beyond the scope of this paper.

For the immediate conditions at Erie it was developed that on an hourly basis over a ten year period the wind expectations were approximately in percentages; down lake 50, up-lake 20, off-shore 10 and on-shore 20. The lake topography at Erie played a very considerable rôle in its effect on lake currents, since the narrowed "neck" between Erie and the Canadian shore, tended to speed up the down- and up-lake currents; and Presque Isle Peninsula behind which the

water works intake was shielded, interposed an effective barrier against the travel to the water intake, of up-lake currents. Evidence of probable contamination were discovered but such occurrences were quite limited in number, and for the most part, seemed to require the combination of winds from the South followed by heavy westerly winds (bringing seiche conditions) for their occurrence. This combination occurred relatively seldom, and was not always accompanied by evidences of contamination. Contaminated water in making a "left-turn" around the peninsula would be subject to considerable dilution, and the degree of pollution thereby limited.

This paper is offered as a contribution to a discussion of some of the factors affecting current movements. It is hoped it will help throw some light on the causes leading to the dissemination of contamination. It is believed that on the shore of any body of water there are certain fairly definite principles which may be discovered from which the combinations leading to the dissemination of contamination may be inferred with some degree of assurance. The position of the shore with respect to the prevailing winds; the lake topography in its immediate vicinity; the position of the lake's axis with respect to directions of heavy "seiche" winds; the effect of "seiche-waves" on the given shore; and the action of ice are some of the major factors which color the problem. The same answer will not be returned in each case, but it is believed that among others the foregoing factors can profitably be considered in any study.

THE PREVENTION OF CORROSION OF PIPE[1]

By William W. Brush[2]

The condition of a pipe recently uncovered in the Brooklyn portion of the New York distribution system is of special interest as it brings to us in a striking manner the effect of adequate protection of the metal and the condition that develops with a soft corrosive water with inadequate protection of the metal.

Figure 1 is a photograph of two sections of 6-inch pipe. The one on the left is a portion of the original distribution system of Brooklyn laid in 1857 and which was taken out this year. One can see the extent to which corrosion has obstructed the opening in the pipe, not by the depositing of muck, but by the growth of the rust tubercles inside the pipe. On the right one may see the condition of a pipe laid in 1863 and that was discovered when the Board of Water Supply was installing a 72-inch steel pipe and uncovered this portion of the distribution system in the trench for the large pipe. The pipe was in such remarkable condition of preservation as to the outside, in showing freedom from rust, that we made an examination of the inside of the pipe and found that also to be remarkably free from any rust encrustation. It is entirely different from the majority of the pipes in the Brooklyn system that were laid many years ago.

In general, our experience has indicated, during the removal of some fifty odd miles of small mains during the last 20 years, that the old pipes laid prior to 1870 are generally in a somewhat similar condition to the encrusted pipe shown on the right. Therefore, this particular pipe does not represent the condition of the pipes laid in the '60s, but only the condition of this one particular line. We have found nothing else in the system that approaches this condition.

The question then arises as to why that condition exists and I do not intend to go into the condition of the metal or of the coating,

[1] Presented before the New York Section meeting, January 21, 1926.

[2] Deputy Chief Engineer, Department Water Supply, Gas and Electricity, New York, N. Y.

but I shall ask Mr. Leonard Wood of the Board of Water Supply to inform you, because he has had some examinations made in the laboratory and he can best tell you firsthand the results of those examinations. I believe, however, that with the present information we have we would come to the conclusion that it was the coating, in all probability, that gave us this freedom from rust. The pipe on the right has the same carrying capacity that it had when it was laid over sixty years ago. The pipe on the left has a carrying capacity of perhaps a fifth of its original capacity. When we examine the pipes laid in the New York City system in Brooklyn, we find that the

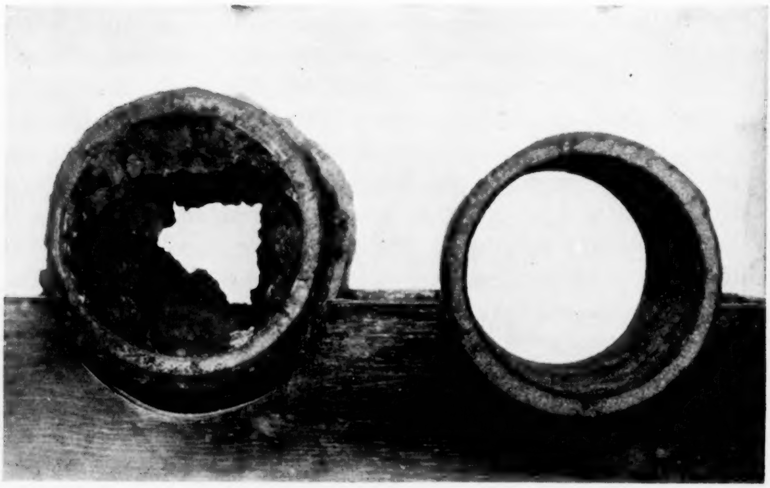


Fig. 1. Showing the Two Sections of 6-inch Pipe Taken in 1925 from the Brooklyn Distribution System. On the Left, Pipe Was Laid in 1857, while on the Right, the Pipe Was Laid in 1863.

condition as to tuberculation is progressive, but after 10 years you will find the rust tubercles usually are a half inch or so in diameter and cover a very appreciable portion of the area of the pipe. These tubercles increase in size and in number as time goes on, so that after 20 year or so the tubercles are usually an inch or so in depth. We have found with the Catskill water, which is a very soft water, the tuberculation or corrosion is progressing much more rapidly than with the water furnished to Brooklyn prior to 1917. This water, when this pipe was laid in '63, was surface water from the south side of Long Island and was later changed to a mixture of surface and sub-

surface water and towards the end of the period that lapsed between the introduction of the public supply in '58 and the introduction of the Catskill supply in 1917, became almost wholly a sub-surface water, drawn from the sands and gravels on the south side of Long Island.

Where this pipe was laid in the Eastern District Section of Brooklyn, the sand is the usual yellow sand found on the South side of Long Island, not corrosive, and generally there is no difficulty from corrosion in and around New York City from soil conditions. The pipe that you see on the left is not seriously affected as far as the outside is concerned, although there is quite a large mass of material adhering to the pipe from the cementing effect of what slight rusting has taken place on the outside. The corroded pipe has lost half of its effective thickness by corrosion. It was removed because it was giving a great deal of trouble from leakage and it was practically impossible to put a tap in it on account of the thinness of the wall resulting from corrosion.

You will probably be interested in the conditions that we find in some of our later installations. In Brooklyn, we have a 48-inch steel pipe that was laid in 1910. Recent examination of that pipe showed that tuberculation had taken place so that the tubercles were an inch or more in depth and the iron had been destroyed to a depth of about an eighth of an inch. In about every fifth pipe length there were large masses of these tubercles covering perhaps a quarter of the area of the metal. Generally, the tubercles were scattered and Mr. Wood can tell you better than I, because he made more detailed examination of the pipe, the frequency of these tubercles, but our judgment is that that steel pipe now should be put out of service, completely cleaned, both the coating as well as the rust removed, the surface thoroughly dried and the pipe recoated from the inside. We are not concerned about the outside as far as our experience goes with this and other steel pipes on account of the slow rate of corrosion in the soils that we have on Long Island. To recoat that pipe will cost probably about ten cents a square foot or about a dollar thirty a running foot for the 48-inch pipe.

Running from Brooklyn to Queens there is a 48 inch cast iron pipe that was laid by the Board of Water Supply and put into use in 1913. This pipe has carried Catskill water since 1917 and shows tubercles an inch or more in depth, these tubercles being scattered generally over the interior of the pipe surface. On special cast-

ings and valves the tubercles very largely cover the surface of the metal. The condition of this pipe is such that it would be economical to thoroughly clean it and recoat it to restore approximately the original carrying capacity of the pipe line. The tuberculated condition is at least equal in number and size of tubercles to that experienced after use of about twenty years with water from the old Brooklyn supply, and 30 or 40 years with the Croton supply. This difference is probably accounted for by the more corrosive effect of the Catskill water, rather than by any difference in the character of the coating applied, which was the usual dip applied to cast iron pipes at the foundry.

We are endeavoring so to design the New York City water supply system that any conduit or pipe line, no matter what its size, may be put out of service without crippling the supply available for domestic consumption and fire extinguishment purposes. If we have a system designed that way, there is no serious difficulty in recoating a large steel pipe or cast iron pipe after a period of 15, 20 or 25 years.

The cast-iron pipe I earlier referred to that runs from Brooklyn to Queens is now in a condition where, in my judgment, it should be put out of service, cleaned and recoated for the purpose of raising the coefficient of flow and also for the purpose of preserving the pipe, but mainly to increase the flow through the pipe and to increase it for a long period of time.

This particular pipe that I speak of cannot be put out of service until another line which is now being laid is completed and put into service.

The question of preserving approximately the full carrying capacity of our pipe lines that are used in the eastern and southern portion of the United States, where corrosion is a serious factor, is of such importance that every example of extensive corrosion that comes up, should be brought to your attention in a way that will lead to further thought and consideration of this very important problem. The determination of the solution of this problem is of great interest to the waterworks fraternity generally and especially to those of us who have to deal with corrosive waters.

DISCUSSION

LEONARD P. WOOD:[3] I can add little to what Mr. Brush has told you about this remarkably preserved pipe, except to quote the analyses of the iron and of the coating. As Mr. Brush has said, the coating is of unusual thickness; a careful comparison of sections of both kinds of pipe shows the coating on the 1863 pipe to be, in the thinnest places, at least 4 to 5 times as thick as the coatings we are getting today on pipe of the same size and larger. The analysis of the coating, which the chemist says is a coal tar, is as follows:

	Per cent
Bituminous material, soluble in carbon disulphide	21.00
Mineral matter (ash)	66.05
Bituminous material insoluble in carbon disulphide:	
Free carbon (loss on combustion)	12.95
	100.00

The coating is strong and hard and glossy and, as shown by the slide and the specimen, has shown remarkable life.

As to the metal itself, the striking differences from the ordinary pipe metal of today are in the low phosphorous and manganese content and the high silicon. Phosphorus and manganese are each from about four-tenths to one-fifth, and silicon from one and one-half to more than three times the quantities present in other cast-iron pipes with which I am familiar, some of which other pipes have shown extremely rapid corrosion with the same water. The analysis of two samples follow:

	A	B
	per cent	*per cent*
Sulphur	0.075	0.081
Phosphorus	0.108	0.108
Silicon	2.90	2.63
Manganese	0.11	0.12
Carbon, graphitic	2.50	2.60

[3] Assistant Engineer, Board of Water Supply, New York, N. Y

Is it not possible that the unusual chemical composition of the iron may have had something to do with the durability of this pipe?

Another point of interest is the rough interior surface of the pipe as seen on removing the coating. This pipe was apparently cast against a rough sand core, probably green sand, which had not been smoothed up with any foundry facing.

With regard to the 48-inch cast-iron pipe of which Mr. Brush has spoken, and which, through Mr. Brush's courtesy, I was able to examine 2 years ago, the tuberculation throughout most of that pipe was decidedly marked, tubercles averaging about 30 per square foot, $\frac{3}{4}$-inch to 1-inch in diameter, and about $\frac{5}{8}$-inch high, after 9 years of service. One of the most striking things was the difference between the condition of the straight pipes and the special castings furnished by the same manufacturer, but which I believe were cast in separate foundries. The special castings were studded with very large tubercles, covering, in different places, from about 20 per cent to about 80 per cent of the surface of the metal, averaging about 50 per cent, and generally $1\frac{1}{2}$ to 2 inches in diameter by about 1-inch high. Depth of pitting under these tubercles was about 0.2 inch. This pipe was cast in 1911 and 1912, and tests made on the line a short time before the inspection indicated that in nine years it had lost about 40 per cent of its original carrying capacity.

The pipe was purchased under the American Water Works Association specifications, except for the strength test of the iron which was in accordance with the specifications of the American Society for Testing Materials. Analyses of the iron in the straight pipe and the special castings failed to show anything unusual. The principal difference between the analyses was that the special castings showed a greater variation in chemical composition between different samples from the same casting, than did the straight pipe. The scleroscope showed a variable hardness in both, but no outstanding difference between the straight pipe and the specials.

The coating on this 48-inch pipe was appreciably thicker on the straight pipe than on the special castings. It was also appreciably thicker on some of the straight pipe than on others, though thin on all. It had more toughness and luster, also, on the straight pipe than on the specials. How far the difference in tuberculation between the straight pipes and the specials was due to the difference in quality and thickness of the coating, and how far it was due to the difference in the uniformity of composition of the iron, is a question.

Now just where does all this lead us? If this 48-inch line which has lost 40 per cent of its carrying capacity in 9 years is typical, we are throwing away, due to the lack of effective methods of protecting cast-iron pipe, something like 40 per cent of our investment in iron pipe. New York is putting about five million dollars a year into the ground in the form of cast-iron pipe. Of course, a pipe of any kind is rarely called upon to do full duty in less than 10 years. In other words, New York City is buying each year five million dollars worth of carrying capacity to be delivered 10 years hence. If in 10 years we have lost 40 per cent of it, we have thrown away, through our inability to get pipe that will not tuberculate, two million dollars a year. That is a picture of the size of the corrosion problem in New York City. Mr. Brush has shown that it is possible to make a tar-coated cast iron pipe which will last practically without deterioration for sixty years, but we do not get it. Instead we are laying pipes which, like the 48-inch pipe mentioned, lose forty per cent of their carrying capacity in 9 years. This is a serious problem, Are we going to keep on putting money into the ground with the definite knowledge that we are throwing away 40 per cent of our investment or are we going to face the problem squarely and try to find the answer? Mr. Brush has shown there is an answer; are we going to find it?

C. W. Sherman:[4] Mr. Wood has raised the question: How are we going to find the answer? That is a question which ought to be given most attention. Personally, I think I am getting somewhere near a solution in my own practice. At the present moment, I am going to lay some cement lines. I am not certain whether that is the answer, but I think it is the most promising of anything we have at present. We all know that our tar-coated iron pipes do not get the same coating as some of the earlier ones did. It is probable also that the character of the tar-coating varies somewhat with the relative smoothness of the interior surface of the cast-iron pipe. I have also been inclined to believe that the tar-coating protected a smooth interior surface. We know that tubercles start at small points, that the pipe not badly tuberculated seems nearly clear when you brush off the tubercles. It seems to me probable that those tubercles developed at points where there was a projection of iron and where the cooling of the tar covered it with a thin film, while

[4] Consulting Engineer, Boston, Mass.

between the hillocks there was a thicker film of tar that seemed to offer an explanation of how the tubercles started. Of course, once started they develop and continue to develop at increasing rate of speed. The matter has been called to my attention with special forcefulness in the last few months as I have had occasion to make a number of investigations in Boston. I have been surprised to find 6, 8 and 10-inch pipes that have lost half of their carrying capacity in 20 to 25 years. It is a very serious situation. What we can do to help those old pipes is another question deserving of consideration. Possibly my present solution of cement lining on further extensions will result in greatly increasing their useful life, but what are we going to do with the millions of dollars which we have invested in the ground. There is a chance for the inventive genius of this Association to exert itself.

W. W. Brush:[2] Personally, my mind has been traveling along the same track as Mr. Sherman's as to the protection of cast-iron pipe from corrosion, that is, by cement lining. We are endeavoring to get to a point where we can call for cement lined cast-iron pipe in the foundries for New York City service. Some of our other communities have gone ahead much more rapidly than we have and are using only cement lined pipe and with very successful results. The cement lining is approximately $\frac{1}{8}$ to $\frac{1}{4}$ inch in thickness. In one point I find that this particular pipe does not support Mr. Sherman, that is as to the question of protection with smooth-surfaced iron. This pipe is extremely rough or irregular in the surface of the iron and the coating seems to adhere very well under those conditions and the coating bridges over or covers over the high points of the iron. Examination by metallurgists under the microscope of the iron of these two pipes has indicated that the Scotch iron is what would normally be determined by metallurgists as being a superior iron. It is a finer grained iron and the carbon is much better mixed with the iron than the American pipe. The information that has been given to me today is that the American pipe represents about normal American cast iron as used in pipe foundry practice for many years past and that there is no special reason that can be determined from microscopical examination as to why the pipe should not have rusted. There are some large tubercles in the Florence iron pipe but they are seldom encountered. The only ones that I saw (I have only seen a few sections of pipe) represented a line of tubercles near the bell where possibly some instrument had scratched or removed the coating. It was an irregular line 4 or 5 inches in length. Along that line there was the usual rust tubercle of about the size you find after fifty years of use.

THE EFFECT OF FRESH COLOR ON COAGULATION AT THE CAMBRIDGE, MASSACHUSETTS WATER PURIFICATION WORKS

By Harold C. Chandler[1]

The rapid sand filters at Cambridge, Mass., were put into service in April, 1923. Raw water flows to the filter plant by gravity from the Stony Brook impounding reservoir which is 7 miles distant, or, if the Stony Brook water is insufficient in volume, the deficiency is made up by pumping from Fresh Pond, on the shores of which the plant is located. The purification process consists of coagulation with alum, sedimentation, filtration, aeration, and treatment with chlorine and soda ash.

One of the most important problems that has been encountered is that of getting good coagulation during the cold months of the year. Temperature alone is not the controlling factor. The greatest difficulty is encountered during heavy run-off, which brings fresh color from the swamps on the drainage area of Stony Brook.

The detention period in the coagulation basin is theoretically only two and one-half hours, but actually somewhat less than two and one-half hours. The raw water after a heavy run-off has had very little storage and contains 60 to 70 parts per million of color. At such times it is difficult to get good coagulation within the period of detention provided by the basin. Precipitation has barely begun when the treated water reaches the filters and the floc is so finely divided that "breaking" occurs at 5 or 6 feet loss of head. This is accompanied by increase of color, alum compounds and bacteria in the effluent.

Attempts have been made to produce better mixing and thereby hasten floc formation in the coagulation basin. Vertical baffle boards with openings arranged in different ways have been installed at varying distances from the inlet. These have accomplished very little.

[1] Chemist, Water Purification Works, Cambridge, Mass.

Following a heavy run-off the alkalinity of the raw water is so low (10 parts per million) that the alum dose cannot be maintained at the usual rate of 1.4 grains per gallon. The design of the plant is such that soda ash can be added to the raw water, but there is nothing to be gained by so doing as soda ash always peptizes the color, making coagulation still more difficult.

Previous to December, 1925, it had been possible by limiting the filter runs to a final loss of head of 6 or 7 feet to produce at these times of heavy run-off filtered water having a color of less than 10 and little or no turbidity.

In December, 1925, a very heavy rainfall brought about a rapid change in the quality of Stony Brook water, as shown in the following table:

	DECEMBER 4	DECEMBER 8	FEBRUARY 10
Color	40	62	44
Alkalinity	12.0	10.0	10.5
CO_2	2.0	3.5	7.0
pH	6.8	6.6	6.4

Difficulties immediately manifested themselves. The coloring matter was refractory to alum treatment, the floc was fine and settled poorly and the filters were subject to breaking at very low losses of head.

The remedy for the situation was the use of a mixed raw water, to be obtained by pumping water from Fresh Pond and mixing it with Stony Brook water in the ratio of 40 per cent Fresh Pond and 60 per cent Stony Brook. Fresh Pond holds 1400 million gallons and affords a considerable period of storage to its water, as only 1 or 2 million gallons are withdrawn from it daily throughout most of the year.

The color of Fresh Pond water was 11. The mixture of Fresh Pond and Stony Brook water had a lower color and higher alkalinity (45 and 16, respectively) than Stony Brook water, and produced a floc good enough to bring about surface removal on the filters. This made it possible to run the latter to the maximum loss of head (9 feet) without "breaking."

The additional expense entailed by continuous pumping from Fresh Pond was nearly balanced by the saving in soda applied to the filtered

water for correcting corrosive tendencies. As the carbonic acid content of Stony Brook water increased to 7 parts per million and the alkalinity dropped to 10 parts per million, while in the mixed raw water the figures were 5 and 16, respectively, it is of course obvious that more soda would have to be used if Stony Brook water alone were treated. The saving in soda amounted to 6 parts per million, or 50 pounds per million gallons.

Bottle experiments in the laboratory, as well as actual plant operation (basin removal, condition of floc on filters, filter effluent color and alum in the filter effluent) have always shown that Fresh Pond water or a mixture of Fresh Pond and Stony Brook coagulates better than Stony Brook water alone.

This may be due to one or more of the following reasons:

1. Long storage in Fresh Pond has allowed the original smaller color particles to aggregate, forming larger particles which are easier to coagulate and precipitate.

In Stony Brook water the fresh color particles were in a very fine state of division. This is shown to a certain extent by the following color readings:

	Apparent color	True color (filtered)	Per cent decrease upon filtering
Fresh Pond	16	13	20
Stony Brook	36	34	5

2. There were present in fairly large numbers in Fresh Pond algae of a siliceous character, such as synedra, whereas in Stony Brook water there were only a few scattered forms.

	Standard units per cubic centimeter
Fresh Pond	2500
Stony Brook	16

These algae aid coagulation in the same way that clay does, as shown by the following bottle experiments:

	ALUM DOSE	FLOC	PRECIPITATE
	grains per gallon	*minutes*	*minutes*
Fresh Pond water	1.2	10	45
	1.5	2	15
Fresh Pond water filtered through paper to remove algae	1.2	30	90
	1.5	3	20

The following bottle experiments show the effect of adding 10 parts per million of standard turbidity to Stony Brook water:

ALUM DOSE	STONY BROOK WATER		STONY BROOK WATER PLUS 10 P.P.M. TURBIDITY	
	Floc	Precipitate	Floc	Precipitate
grains per gallon	*hours*	*hours*	*hours*	*hours*
1.2	$2\frac{3}{4}$	Over night	2	3
1.4	$2\frac{1}{2}$	$4\frac{1}{4}$	$1\frac{1}{2}$	$2\frac{1}{2}$
1.6	2	$3\frac{1}{4}$	$1\frac{1}{4}$	2

3. Miller has pointed out that in the case of iron hydroxide floc there is a greater tendency for floc formed at low pH values to disperse on washing than for floc formed at higher pH values (Miller, U. S. Public Health Report, on Iron Compounds and Water Clarification, Reprint No. 1023, July 3, 1925). Miller also states that "ferric floc" possesses many of the properties of "alum floc."

It is probably true that there is more floc dispersion at the lower pH value of Stony Brook treated water (5.60) than at the higher pH value of 6.50 in Fresh Pond treated water. The coagulation process, as ordinarily conducted, promotes dispersion when conditions are right, for the floc is being continually washed in passing through the basin and after reaching the filters.

The following bottle experiments show the actual differences in the coagulation of Fresh Pond and Stony Brook water during December, 1925.

ALUM DOSE	STONY BROOK		FRESH POND	
	Floc	Precipitate	Floc	Precipitate
grains per gallon				
0.8	Nothing	Over night	1¼ hours	Over night
1.0	Nothing	Over night	35 minutes	Over night
1.2	Nothing	Over night	11 minutes	1½ hours
1.4	2½ hours	5 hours	8 minutes	40 minutes
1.6	1¼ hours	2¾ hours	5 minutes	22 minutes
1.8	1 hour	2¼ hours	2 minutes	10 minutes

Raw water analysis

	STONY BROOK	FRESH POND
Color	60	13
Turbidity	1	3
Alkalinity	10	29
pH value	6.70	7.70

It was thought that Fresh Pond water might coagulate better than Stony Brook water partly because there was so much less color in Fresh Pond water. Investigation showed that this was not true. Dilutions of Stony Brook water were made, and it was found that the diluted samples required just as much alum as the undiluted samples. It was also suspected that Fresh Pond water contained a greater proportion of negative color colloids than Stony Brook. These would have their charges neutralized by the positive charge of the aluminum hydroxide colloid and so tend to precipitate. Cataphoresis experiments did not show this to be the case.

This system of using a mixed raw water was successfully carried out through December, January February and March. Analysis of the final effluent during these months gave the following average results:

	TURBIDITY	COLOR	ALKALINITY	CO_2	pH	BACTERIA PER CUBIC CENTIMETER		B. COLI PER 100 cc.
						20°C.	37°C.	
December	−1	4	15.0	3.5	6.80	17	3	0
January	−1	5	18.0	3.5	6.85	12	3	0
February	−1	4	19.0	4.0	6.85	7	3	0
March	−1	6	19.5	4.5	6.80	6	2	0

The alum dose was 1.6 grains per gallon.

Analysis of the mixed raw water during this period gave the following average results:

	TURBIDITY	COLOR	ALKALINITY	CO_2	pH	BACTERIA PER CUBIC CENTIMETER		B. COLI PER 100 cc.
						20°C.	37°C.	
December	3	47	16.0	2.5	6.85	650	170	14
January	2	41	16.0	4.0	6.75	475	120	10
February	2	36	15.5	4.0	6.70	425	90	4
March	2	37	15.0	5.5	6.65	425	90	6

TYPHOID FEVER IN THE LARGE CITIES OF THE UNITED STATES IN 1925[1]

The Journal presents its fourteenth annual survey[2] of typhoid fever mortality in the seventy-seven cities of the United States that had more than 100,000 population in 1925.[3] As in the thirteenth report, the cities have been grouped according to the recognized geographic divisions of the United States Census Bureau. Since 1920, eight cities have been added to the list of cities with more than 100,000 population (El Paso, Lynn, Duluth, Utica, San Diego, Canton, Flint, Tulsa) and these appear for the first time in our tables.

The cities of the New England group (table 1) again make a very favorable showing. All but four of the New England cities achieve a place on the Honor Roll (rates less than 2.0 per hundred thousand), and one city (Lowell, Mass.) has the distinction of remaining free from any typhoid death. The full five-year comparison (1921-1925) which this year becomes available renders possible a more satisfactory appraisal of the actual typhoid situation in communities like these New England cities, where the yearly typhoid deaths are now so few. In such a comparison it appears that in every city in this group but one the average annual rate was lower for 1921–1925 than for any preceding five-year period. In 1916–1920, seven of the New England cities had rates above 4.0; in 1921–1925, only two cities were above this figure. The five-year averages show particular improvement in New Bedford and Fall River. New Bedford carries off the

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[2] The preceding articles were published in Jour. Amer. Med. Assoc., May 31, 1913, p. 1702; May 9, 1914, p. 1473; April 15, 1915, p. 1322; April 22, 1916, p. 1305; March 17, 1917, p. 845; March 16, 1918, p. 777; April 5, 1919, p. 997; March 6, 1920, p. 672; March 26, 1921, p. 860; March 25, 1922, p. 890; March 10, 1923, p. 691; February 2, 1924, p. 389, and March 14, 1925, p. 813.

[3] The deaths from typhoid in each city are those reported to us by the respective health departments. The rates have been calculated on the basis of midyear 1925 population, estimated by the method of the United States Census Bureau, save that in several instances in which no census estimate is available other estimates are used. These are duly noted in the tables.

TABLE 1

Death rates of cities in New England states from typhoid per hundred thousand population

	1925	1924	1921–1925	1916–1920	1911–1915	1906–1910
Lowell	0.0	1.7	2.4	5.2	10.2	13.9
New Bedford	0.8	4.5	1.7	6.0	15.0	16.1
Lynn	1.0	2.7	1.6	3.9	7.2	14.1
Springfield	1.4	1.3	2.0	4.4	17.6	
Fall River	1.5	0.0	2.3	8.5	13.4	13.5
Cambridge	1.7	4.5	4.3	2.5	4.0	9.8
New Haven	1.7	5.1	4.4	6.8	18.2	30.8
Hartford	1.9	0.0	2.5	6.0	15.0	19.0
Worchester	2.1	0.5	2.3	3.5	5.0	11.8
Bridgeport	2.8*	3.5	2.2	4.8	5.0	10.3
Providence	3.4	2.5	1.8	3.8	8.7	21.5
Boston	3.5	2.1	2.2	2.5	9.0	16.0

* Rate calculated on figures for population in 1922.

TABLE 2

Death rates of cities in Middle Atlantic states from typhoid fever per hundred thousand population

	1925	1924	1921–1925	1916–1920	1911–1915	1906–1910
Scranton	0.0	2.8	2.4	3.8	9.3	31.5
Newark	0.9	2.7	2.3	3.3	6.8	14.6
Reading	0.9	5.4	6.0	10.0	31.9	42.0
Yonkers	1.8	2.7	1.7	4.8	5.0	10.3
Rochester	1.9	1.2	2.1	2.9	9.6	12.8
Paterson	2.1	3.6	3.3	4.1	9.1	19.3
Syracuse	2.2	1.6	2.3	7.7	12.3	15.6
Philadelphia	2.3	2.2	2.2	4.9	11.2	41.7
Pittsburgh	3.2	3.9	3.9	7.7	15.9	65.0
New York	3.3*	3.1	2.6	3.2	8.0	13.5
Trenton	3.8	0.8	8.2	8.6	22.3	
Utica	3.9					
Jersey City	4.1	2.6	2.7	4.5	7.2	12.6
Buffalo	4.5	2.8	3.9	8.1	15.4	22.8
Albany	5.9	12.6	5.6	8.0	18.6	17.4
Camden	7.0	6.3	5.9	4.9	4.5	

* Rate calculated on figures for population in 1924 with same annual increment added as in 1922–1923 and 1923–1924.

palm for the lowest quinquennial average ever reached in this group, with Providence a close second. The single exception to this almost unbroken record of improvement is Cambridge, which maintained a very low rate in 1916–1920 (2.5), but had an exceptionally bad year (10.8) in 1921, thus bringing up its average for the quinquennium in 1921–1925. In 1925, perhaps the most noteworthy change is that in Boston, which for the second successive year shows a typhoid increase, and for the first time in years stands at the foot of the New England cities. New Haven reports the lowest rate in its history, and Lynn, the newcomer in the list makes a remarkably fine showing.

In the Middle Atlantic States (table 2) we find the only other American city (Scranton) besides Lowell reporting no typhoid

TABLE 3

Death rates of cities in South Atlantic states from typhoid per hundred thousand population

	1925	1924	1921–1925	1916–1920	1911–1915	1906–1910
Norfolk, Va.	1.5*	2.9	2.8			
Wilmington	3.3	8.3	4.7			
Baltimore	3.6	2.8	4.0	11.8	23.7	35.1
Washington	5.0	4.3	5.4	9.5	17.2	36.7
Richmond	5.4	7.6†	5.7	9.7	15.7	34.0
Atlanta	18.4‡	15.0	14.5	14.2	31.4	58.4

* Rate calculated on figures for population in 1924 with same annual increment added as in 1922–1923 and 1923–1924.

† Erroneously given as 1.1 in typhoid survey for 1924.

‡ Rate calculated on population figures furnished by the health department.

deaths for 1925. From the quinquennial comparison it appears that fourteen of the fifteen cities in this group had a lower average in 1921–1925 than in 1916–1920. The single exception (Camden) evidently has a typhoid situation that needs examination. While typhoid rates all over the United States have been falling, the five-year average in Camden has steadily increased from 4.5 in 1911–1915 and 4.9 in 1916–1920, to 5.9 in 1921–1925. Moreover, the rates for 1924 (6.3) and 1925 (7.0) are higher than the 1921–1925 average. There must be some local reason for this constant upward trend. Compared with 1924, seven cities in this group had a lower rate in 1925, eight a higher. The increase in New York and perhaps in some other localities may doubtless be attributed in part to the

oyster-borne infection, which swelled the list of typhoid deaths toward the end of 1924 and carried over into the first quarter of 1925. Typhoid deaths in New York for example, numbered sixty-seven in the first quarter of 1925, as compared with eighteen in the corresponding quarter of 1924. The increased number of cases due to contaminated oysters unquestionably led to an increase in the number of carriers and also to an increase in contact cases.

The four cities in the South Atlantic states (table 3) for which a comparison of five-year averages is possible showed a marked improvement in three instances (Baltimore, Washington, Richmond) and a

TABLE 4

Death rates of cities in East North Central states from typhoid per hundred thousand population

	1925	1924	1921–1925	1916–1920	1911–1915	1906–1910
Canton	0.9					
Grand Rapids	1.3	3.4	1.9	9.1	25.5	29.7
Milwaukee	1.4	1.0	1.6	6.5	13.6	27.0
Chicago	1.5	1.6	1.4	2.4	8.2	15.8
Cleveland	1.5	1.2	2.0	4.0	10.0	15.7
Flint	1.5					
Dayton	1.7	2.4	3.3	9.3	14.8	22.5
Akron	1.9*	1.0	2.4			
Youngstown	2.5	4.5	7.2			
Detroit	2.7	3.0	4.1	8.1	15.4	22.8
Indianapolis	3.6	3.9	4.6	10.3	20.5	30.4
Cincinnati	4.2	2.5	3.2	3.4	7.8	30.1
Columbus	4.3	3.7	3.5	7.1	15.8	40.0
Toledo	6.3	4.4	5.8	10.6	31.4	37.5

* Rate calculated on figures for population in 1924.

practically stationary condition in the other (Atlanta). Atlanta, like the other Southern cities, faces a difficult situation; but is it really any worse than that of Birmingham, which in 1916–1920 had a typhoid average twice as high as that of Atlanta, but in 1921–1925 one that was considerably lower?

The cities in the East North Central states (table 4) have a perfectly clear record, every one of the ten cities for which data are available showing a lower average for 1921–1925 than for 1916–1920. The reduction in Grand Rapids is particularly noteworthy. Chicago holds the lowest typhoid record for the last five-year period.

In this group six cities had lower rates in 1925 than in 1924, and six higher. The two newcomers in the list, Canton and Flint, start out with very low rates.

The four cities in the East South Central states (table 5) all stand better in 1921–1925 than in 1916–1920, Louisville and Birmingham showing marked improvement. That Memphis still has a milk problem on its hands is shown by a recent study of the milk supply

TABLE 5

Death rates of cities in East South Central states from typhoid per hundred thousand population

	1925	1924	1921–1925	1916–1920	1911–1915	1906–1910
Louisville	5.8	1.9	4.9	9.7	19.7	52.7
Birmingham	9.2	7.5	10.8	31.5		
Nashville	19.8	20.4	17.8	20.7	40.2	61.2
Memphis	28.6	41.2	20.3	27.7	42.5	35.3

TABLE 6

Death rates of cities in West North Central states from typhoid per hundred thousand population

	1925	1924	1921–1925	1916–1920	1911–1915	1906–1910
Duluth	0.9					
Kansas City, Mo	1.9	3.6	5.7	10.6	16.2	35.6
Omaha	1.9	1.0	3.3	5.7	14.9	40.7
St. Paul	2.8	2.0	3.4	3.1	9.2	12.8
Minneapolis	3.3	2.1	1.9	5.0	10.6	32.1
St. Louis	3.9	3.7	3.9	6.5	12.1	14.7
Des Moines	4.7*	2.8	2.2			
Kansas City, Kansas	7.7	4.6	5.0	9.4		

* Rate calculated on figures for population in 1924 with same annual increment added as in 1922–1923 and 1923–1924.

published by the superintendent of health in 1925. Grading of the milk was found impracticable, and was abandoned in 1923 in favor of published milk scores. Pasteurization is not required; in 1924 about half of the supply (49.7 per cent) was pasteurized. The experience of other communities indicates that pasteurization of a larger proportion of the milk supply would be followed by a further reduction in typhoid.

In the cities of the West North Central states (table 6), none of which in recent years have suffered from excessive typhoid, comparison of the quinquennial averages reveals an almost unbroken improvement, only St. Paul showing a slight increase. With one exception,

TABLE 7

Death rates of cities in West South Central states from typhoid per hundred thousand population

	1925	1924	1921–1925	1916–1920	1911–1915	1906–1910
El Paso	3.8	11.0	10.8	30.7	42.8	
Fort Worth	5.2	1.7	6.1			
Houston	5.5	5.6	7.6			
San Antonio	8.6	5.8	9.3	23.3	29.5	
Dallas	17.5	8.2	11.2	17.2		
New Orleans	19.8	10.0	11.6	17.5	20.9	35.6
Tulsa	20.9					

TABLE 8

Death rates of cities in Mountain and Pacific states from typhoid per hundred thousand population

	1925	1924	1921–1925	1916–1920	1911–1915	1906–1910
San Diego	0.9					
Oakland	1.2	1.3	2.0	3.8	8.7	21.5
Los Angeles	1.3*	4.4	3.0	3.6	10.7	19.0
Spokane	1.8	1.9	4.4	4.9	17.1	50.3
Tacoma	1.9	3.9	3.7	2.9	10.4	19.0
Portland, Ore	2.1†	6.1	3.5	4.5	10.8	23.2
San Francisco	2.2	2.6	2.8	4.6	13.6	27.3
Seattle	2.5‡	3.2	2.6	2.9	5.7	25.2
Denver	5.0	5.1	5.1	5.8	12.0	37.5
Salt Lake City	6.9	10.1	6.0	9.3	13.2	

* Rate calculated on population figures furnished by the health department.

† December 1, 1924, to November 30, 1925.

‡ Rate calculated on figures for population in 1924 with same annual increment added as in 1922–1923 and 1923–1924.

the 1925 rates in this group were higher than those for 1924. Duluth starts out with the very low rate of 0.9.

The cities of the Southwest (table 7) show uniform improvement in the five-year averages so far as data are available. The 1925 rates

TABLE 9

Death rates from typhoid in 1925

Honor roll (from 0.0 to 2.0 deaths per hundred thousand)			
Lowell	0.0	Cleveland	1.5
Scranton	0.0	Fall River	1.5
New Bedford	0.8	Flint	1.5
Canton	0.9	Norfolk, Va	1.5
Duluth	0.9	Cambridge	1.7
Newark	0.9	Dayton	1.7
Reading, Pa	0.9	New Haven	1.7
San Diego	0.9	Spokane	1.8
Lynn	1.0	Yonkers	1.8
Oakland	1.2	Akron	1.9
Los Angeles	1.3	Hartford	1.9
Grand Rapids	1.3	Kansas City, Mo	1.9
Milwaukee	1.4	Omaha	1.9
Springfield, Mass	1.4	Rochester	1.9
Chicago	1.5	Tacoma	1.9
First rank (from 2.0 to 5.0)			
Paterson	2.1	Wilmington	3.3
Portland, Ore	2.1	Providence	3.4
Worcester	2.1	Boston	3.5
San Francisco	2.2	Baltimore	3.6
Syracuse	2.2	Indianapolis	3.6
Philadelphia	2.3	El Paso	3.8
Seattle	2.5	Trenton	3.8
Youngstown	2.5	St. Louis	3.9
Detroit	2.7	Utica	3.9
Bridgeport	2.8	Jersey City	4.1
St. Paul	2.8	Cincinnati	4.2
Pittsburgh	3.2	Columbus	4.3
Minneapolis	3.3	Buffalo	4.5
New York	3.3	Des Moines	4.7
Second rank (from 5.0 to 10.0)			
Denver	5.0	Toledo	6.3
Washington	5.0	Salt Lake City	6.9
Fort Worth	5.2	Camden	7.0
Richmond	5.4	Kansas City, Kan	7.7
Houston	5.5	San Antonio	8.6
Louisville	5.8	Birmingham	9.2
Albany	5.9		
Third rank (from 10.0 to 30.0)			
Dallas	17.5	New Orleans	19.8
Atlanta	18.4	Tulsa	20.9
Nashville	19.8	Memphis	28.6

in Fort Worth, Dallas and New Orleans are considerably higher than those for 1924. El Paso has responded to our request by sending in complete figures for all the years since 1911, the only one besides Lynn of the cities reporting for the first time to render this service. The proportional reduction in typhoid in El Paso is great and the 1925 figures highly encouraging.

All the cities in the Mountain and Pacific states (table 8) had less typhoid in 1925 than in 1924, contrary to what was observed in other geographic divisions. The decrease was especially notable in Los

TABLE 10

Total average typhoid death rate (1910–1925)

	TOTAL POPULATION (59 CITIES)* ESTIMATED BY THE UNITED STATES CENSUS BUREAU METHODS	TYPHOID DEATHS	TYPHOID DEATH RATE PER 100,000
1910	21,125,340	4,143	19.61
1911	21,679,886	3,416	15.71
1912	22,234,865	2,800	12.59
1913	22,788,282	2,923	12.82
1914	23,342,199	2,443	10.46
1915	23,896,616	2,094	8.76
1916	24,368,470	1,874	7.69
1917	24,908,055	1,684	6.76
1918	25,142,605	1,583	6.30
1919	25,702,711	1,006	3.91
1920	26,340,793	934	3.54
1921	26,749,616	992	3.71
1922	27,133,857	862	3.18
1923	27,566,727	866	3.14
1924	28,174,489	870	3.09
1925	28,882,031	993	3.43

* Eighteen cities are omitted from this summary because data for the full period are not available.

Angeles and in Portland. All the five-year averages with one exception (Tacoma) also show a reduction.

The Honor Roll (cities with from 0.0 to 2.0 deaths per hundred thousand) this year numbers thirty (five reporting for the first time), as against eighteen on the list for 1924. There are still six cities in the third rank (rates above 10), Dallas and Tulsa taking the places that Albany and Salt Lake City had last year.

The total average typhoid death rate for fifty-nine cities (table 10)

is the highest reported since 1921. Early in 1925, case reports from various localities indicated that the disease was prevailing excessively. In Connecticut the state department of health stated that for the first four months there was more typhoid than for any similar period in the last three years. A notable excess in the number of cases reported throughout the United States for the first six months of 1925 was remarked on in Public Health Reports, July 17. In some places relatively high typhoid prevalence occurred later in the year. The Maryland state department of health received reports of 197 cases in August, 1925, as compared with 156 in August, 1924. The Ohio state department of health noted an increase of 35 per cent in the cases reported in August, 1925, over the number reported in August, 1924. It is evident that 1925 was a "typhoid year."

TABLE 11

*Typhoid death rates in the various geographic divisions in 1925**

CITIES OF MORE THAN 100,000 POPULATION IN	POPULATION	TYPHOID DEATHS	RATE
New England states	2,308,266	56	2.42
Middle Atlantic states	11,279,063	333	2.95
South Atlantic states	1,354,748	110	8.12
East North Central states	7,344,968	163	2.22
East South Central states	570,012	92	16.14
West North Central states	2,072,228	64	3.09
West South Central states	717,491	103	14.36
Mountain and Pacific states	3,235,255	72	2.22

* The same cities as in table 10.

A new table has been compiled for this summary to show the difference in typhoid mortality in the large cities of the several geographic divisions (table 11). The greater prevalence of typhoid in the southern part of the United States as contrasted with the northern stands out conspicuously in this grouping, the East South Central, West South Central and South Atlantic cities averaging much higher than the rest of the country. Since the largest cities, i.e., those with populations greater than 500,000 are mainly in the Northern states, it is plain that the grouping of cities according to size without respect to geographic location might well lead to mistaken conclusions as to the connection of size with typhoid mortality.

Editorial comment (*Jour. A. M. A.*)

The reason for the substantial and widespread increase in typhoid in the large cities in the United States in 1925, shown in our annual summary, is not clear. This is the most considerable proportional increase (10 per cent) since these summaries were undertaken in 1910. The greater prevalence of the disease is not to be attributed clearly to any universally acting cause, since in one geographic division—the Mountain and Pacific states—the 1925 rates are lower than those for 1924 in every city. In the other geographic divisions, thirty-four cities experienced an increase, twenty-seven a decrease. Various factors may conceivably have been at work. There has obviously been a progressive change in the population with respect to antityphoid inoculation. The protective effect afforded by the army inoculations in 1917–1918 may be wearing off, and pari passu a new uninoculated generation of young males is reaching the typhoid age. It is difficult to deny some weight to this factor, and while it should be operative in the Mountain and Pacific states as well as elsewhere, other causes making for reduction may have obscured it. It seems to be true that in most of the country 1925, like 1921 and 1913, was a "typhoid year." There does not appear to have been any extensive prevalence of water-borne disease, and barring the oyster infection early in the year no particular multiplication of sources of infection seems to have occurred. It is tempting to relate excessive typhoid prevalence over a wide territory to some general factor such as weather conditions, but it will be necessary to collect more data before this aspect of the problem can be profitably approached. In the meantime, the annual fluctuations brought out in these summaries will suggest to epidemiologists various lines of inquiry.

THE PUBLIC WATER SUPPLIES OF MONTANA[1]

By H. B. Foote[2]

When Montana was carved out of the Louisiana Purchase in 1864, it was made the third largest state in the Union. Stretching approximately from 104° to 116° west longitude it is 550 miles from east to west. From the south boundary at parallel 45° to the Canadian line on the north at parallel 49° it is 280 miles wide.

Such a large area embraces a wide range of soil characteristics, topography and natural resources. It is difficult to present all these in such a brief description as this paper pretends to give, but there are certain natural divisions which will be used to give as clear a picture of the situation as is possible.

This is the "Land of the Shining Mountains" and it is here that one first approaches the mighty peaks of the Rockies when traveling westward from the plains on the northern routes. The continental divide runs in a northwest-southeast direction through the western part of the state effectively cutting it into two natural divisions. By far the larger of these lies to the east stretching to the plains. The western portion is all mountainous with the characteristic valleys nestling among the many ranges.

From the standpoint of public water supply it is convenient to consider the state in this way for there are certain characteristics common to each portion. Table 1 shows the result of such a division.

On the west side of the "divide" the public supplies are taken largely from streams and springs. Relatively few wells are used. On the eastern side, however, especially away from the mountains, there are more wells, showing the attempt to avoid the necessity of purifying the more turbid streams, even though it means the use of water of high chemical content in many cases.

[1] Presented before the Montana Section meeting, April 17, 1926.

[2] Director of Water and Sewage Division, State Board of Health, Helena, Mont.

THE EASTERN AREA

The chief topographical features of the eastern side are the catchment areas of the main rivers. Among the largest are those of the Yellowstone, Missouri, Milk and Marias rivers. At the head of the latter lies Marias Pass discovered by John Stevens, the intrepid engineer who drew the line of the Great Northern Railway through it to the west. This pass is marked, at an altitude of 5213 feet, by a statue of him placed by the railway company in 1925, in commemoration of his great service.

TABLE 1

Physical and water supply characteristics of Montana

	WEST OF CONTINENTAL DIVIDE	EAST OF CONTINENTAL DIVIDE	TOTAL
Area and per cent of total	25,011 square miles or 17 per cent	121,986 square miles of 83 per cent	146,997 square miles
Population and per cent cent of total	157,583 or 28.8 per cent	390,010 or 71.2 per cent	547,593 (1920)
Population per square mile	6.3	3.2	3.7
Annual precipitation, inches	15–35	10–20	15.67 (1895-1922) mean for state
Sources of public water supply, wells or springs	9 or 7.7 per cent	50 or 42.7 per cent	59 or 50.4 per cent
Streams	21 or 17.9 per cent	37 or 31.8 per cent	58 or 49.6 per cent

Approximately 18 miles "as the crow flies" north and west towers Triple Divide Peak from whose sides flow waters to the Atlantic, the Pacific and Hudson's Bay. At the base of the mountains in this region the United States Reclamation Service has diverted water from the northern slope to the Milk River basin for irrigation in northern Montana.

In reality the streams of this eastern slope make up the Missouri River basin, this stream being formed by the confluence of the Jefferson, Madison and Gallatin rivers near Three Forks, Montana, and receiving the flow of all the other streams also, as it flows north

and eastward. These streams and their tributaries are the sources of the 37 public water supplies of surface origin. Nine of these are filtered and disinfected with chlorine, while one is filtered only. Nine others are disinfected only, chlorine being used. Others are on tributaries furnishing water of good quality.

The nine filter plants are of the modern rapid sand type located at Glendive, Miles City, Billings and Livingston on the Yellowstone River, Hardin on the Big Horn, Great Falls on the Missouri and Chinook and Harlem (two at Harlem) on the Milk River.

Of the ground sources in this region, from which public water supplies are drawn, at least twelve yield water of undesirably high chemical content, either of calcium, magnesium or sodium compounds. Iron, too, is frequently abundant in them and in one manganese is found which gives trouble in encrusting and clogging pipes and meters.

TABLE 2

Chemical analyses of some ground waters in Montana

SOURCE	TOTAL DISSOLVED SOLIDS*	IRON	CALCIUM	MAGNESIUM	CO_3	HCO_3	SODIUM AND POTASSIUM	Cl	SULPHATE	H_2CO_3
1	1,254.0	0.0	33.0	19.0	0.0	561.0	407.0	8.0	523.0	23.0
2	1,327.0	26.0	125.0	91.0	0.0	619.0	188.0	9.0	552.0	
3†	762.0	0.0	0.0	Trace	55.0	627.0	309.0	21.0	33.0	0.0

* Figures represent parts per million of radicals present.

† Represents water from one stratum of the artesian area in the southeastern part of the state.

Some typical waters of this class are represented by the analyses given in table 2.

It is obviously impossible to generalize briefly upon the quality of water found in such a large area without the danger of misrepresentation. Many localities, however, are forced to make use of such waters as are shown and it is from this part of the state that most inquiries come regarding chemical quality of water, effects of such upon the individual and any means of improvement available. A large number of analyses have been made by the state and the United States Geological Survey and a tentative classification of waters as affecting the human system has been made. It has been found that most individuals are able to develop a degree of tolerance for certain waters

high in chemical content, but there are, no doubt, waters for which no tolerance can be created. Those cities using surface waters in this region have water of better chemical quality generally than those shown above.

An interesting phenomenon observed in the streams on the east slope particularly is the annual flood condition. This occurs with sufficient regularity in the early summer as to be called the "June rise." The volume of water flowing is not unusual, but the fact that the flood stage follows the general occurrence of warm weather and the breaking up of the winter with or without rains produces a high river even though the dust may be blowing from the highway alongside. The amount of snow in the mountains together with the character of the spring or late winter weather is responsible for a high, medium or low flood stage. Operators on the lower Yellowstone particularly are often hard put to handle their plants satisfactorily, since they may find a high flood stage occurring without the usual warning of rainy weather.

A plan to assist these men on any one stream is proposed and we hope will soon be in active operation, which will keep them in weekly or perhaps daily touch with each other by letter or wire, informing them of river stages and changing conditions.

THE WESTERN AREA

On the west side there are two main drainage areas, the Clark's Fork (of the Columbia) and the Kootenai, which supply 23 towns. Eight of these are disinfected with chlorine, all on the Clark's Fork area. Those on the Kootenai are generally taken from points above the sources of contamination.

The waters of these streams are of good chemical quality, for the most part free from turbidity, clear, cold and sparkling. They frequently exhibit in their depth that characteristic beautiful blue color so often seen in mountain streams.

Jerome Alexander, writing in "Science" issue of March 20, 1925, explains this phenomenon as a colloidal one stating that "the large amount of limestone in the Rocky Mountain region seems to be responsible for the peculiar bluish tone of color so often noted in glacial streams there; for the softness of this mineral is especially favorable to the formation of colloidal material as a result of glacial abrasion."

The analysis of one such water is given in table 3.

It is regrettable that such streams must bear to their hurt the burdens imposed by advancing settlement. Attempts are made, however, through coöperation with various state and federal agencies, to restrict their pollution to the minimum, thus conserving their primal beauty and purity as far as possible.

Approximately 49 per cent of the catchment areas of 27 supplies lies within United States Forest Areas and especially on these areas are precautions taken to conserve the beauty and purity of the streams. All United States Forest Supervisors are made deputy health officers and as such give excellent service in assisting in this important work.

TABLE 3

TOTAL DISSOLVED SOLIDS*	IRON	CALCIUM	MAGNESIUM	CO_3	HCO_3	SULPHATES	SODIUM AND POTASSIUM	CHLORIDES
43.0	0	8.0	2.5	0	34	Trace	0	1.0

* Figures are parts per million of radicals.

TABLE 4

OWNERSHIP	NUMBER	INVESTMENT	POPULATION SERVED IN 1920
Municipal	48	$7,324,765.83	126,993
Private	19	9,449,033.77	77,364

Many hot springs are found in the mountainous portions of the state. They are encountered in a region extending in a northwest-southeast direction, which includes the geysers and hot springs of the Yellowstone Park. While many of these waters have not been analyzed those that have exhibit a great range of chemical content and temperature. But relatively few are now exploited for medical purposes, but many are used for bathing and recreation. Probably the hottest has a temperature of 193°F.

Montana is in the goiter belt. During the world war she was fourth in the list of states showing goiter among drafted men, being exceeded only by Idaho, Oregon and Washington. Figures on the incidence in some eight or ten counties leads to the belief that simple goiter is wide spread over the state and efforts are being directed toward a thorough study of this problem from all angles.

The plant investment in 67 of the public water supplies on Decem-

ber 31, 1923 as reported to the Montana Public Service Commission is shown in table 4.

Practically all the smaller communities are served by their own municipalities, while a few large cities are served by private corporations.

The state legislature has taken cognizance of the need of water supplies in rural communities and has enacted provisions for the formation of rural special improvement districts. These are found in Chapter 17, Revised Codes of Montana 1921. They allow the construction and maintenance of sanitary and storm sewers, light plants and water works systems in thickly settled places outside of incorporated cities and towns. Under these provisions several towns unable otherwise to provide such utilities have been able to construct, maintain and operate modern water works systems.

Many different types of systems and equipment are found. Some cities such as Butte, Anaconda, Helena, Philipsburg and Havre have more than one system and type of equipment. Some significant figures are:

Gravity systems without reservoirs	12
Gravity systems with reservoirs	34
Pumping systems with centrifugal pumps	28
Pumping systems with piston pumps	42
Pumping systems using gasoline or oil or both	31
Pumping systems using electricity	48
Pumping systems equipped with steam power	9
(Most of these steam plants are auxiliary and not in daily use)	
Air lift systems	2
In five towns hydro-electric and water supply systems are found combined.	

The use of electricity for pumping is slowly increasing as cheaper power is made available in more communities.

An interesting example of the development and utilization of power in connection with water supply is at Gardner, at the confluence of the Gardner and Yellowstone rivers. The harder and more polluted water of the Gardner river is utilized to develop electrical energy which in turn is used to pump the softer and less contaminated water of the Yellowstone river for public use.

A different, but as interesting a situation, is found at Miles City on the lower Yellowstone where the municipality owns and operates its own water, light and heat departments. At the power plant, coal

and artesian well water are used to generate electricity which in turn is used to pump the water of the Yellowstone river to and from the filtration plant for city uses. This light department campaigns to sell power in the various homes for the pumping of soft artesian water thereby reducing the business of the water department. This situation throws the power and water departments into competition though they are under one management and are both owned by the city.

TABLE 5

POPULATION	NUMBER OF TOWNS	NUMBER OF TOWNS WITH UNMETERED SERVICES		NUMBER OF TOWNS WITH METERED SERVICES										
				Per cent of services metered										Total metered
				Below 25		25–49		50–74		75–99		100		
		Pumping	Gravity	P*	G*	P	G	P	G	P	G	P	G	
Over 15,000.....	3			2†						1				3
Over 10,000 to 15,000........	3		1		2									2
5,000 to 10,000..	5			1	1			1		2				5
1,000 to 5,000...	18	1	4‡	3‡	2‡	1		2		3	1	1		13
Below 1,000.....	27	5	7	5	1‡	1		3	1	3		1		15
Totals........	56	6	12											38

* P, pumping systems; G, gravity systems.

† One of these has both pumping and gravity on three systems.

‡ Combined pumping and gravity on one supply

In fact, the state is replete with interesting situations which are the outgrowth, in many instances, of developmental and progressive conditions. Much in the way of improvement in equipment and efficiency lies ahead. In fact, we have just a little more than started as most of our plants have been installed since 1900.

Data relative to meterage are comparatively complete to December 31, 1924 from 56 cities and towns having a total of 67 supplies. These figures appear in table 5.

Opposition to meterage has been especially strong in those cities whose water supplies come by gravity from the mountain streams, water users in such situations being apparently of the opinion that such water should be available for unstinted use.

Such a policy has resulted in some instances in the building of extensive water collection systems rather than in the restriction of use, although the latter has frequently been resorted to in nearly every town. It is probable that meterage will increase markedly in the next few years.

While the general sanitary conditions of almost all our public water supplies are well cared for, there is much to be desired in the way of improvement in chemical and physical quality. Especially is this true in the eastern portion. More filtering plants are needed and softening will in time be generally employed, as our population increases. Refinement in quality is to be sought.

The State Board of Health maintains a separate laboratory for chemical and bacteriological analyses of water and makes a routine practice of examining samples for all public supplies. In addition many samples are submitted from private, school and other supplies for analysis and interpretation.

A distinct step toward the better correlation of activities, and the spreading of information concerning every phase of the water supply business is seen in the formation of the Montana Section of the American Water Works Association. This was effected in 1925. Approximately 25 per cent of the managers and superintendents are now members of this organization and the indications are that in another year there will be at least 50 per cent so organized.

GOITER AND THE PUBLIC WATER SUPPLY[1]

By H. M. Johnson[2]

As stated in a previous paper I had on the subject at Helena in February, 1925, goiter is an enlargement of the thyroid gland. The medical fraternity has established the fact that iodine is necessary for the normal functioning of the thyroid gland and that simple goiters are caused by the lack of iodine necessary for the human system.

We reside in what is termed a goiter district. Constant leaching of salt deposits has exhausted the supply of iodine from our soil and natural waters which accounts for the prevalence of goiter in inland and high places and its absence in the vicinity of the sea.

Our diet does not consist of things containing the required amount of iodine, as is the case of those residing close to salt water. Consequently it is necessary for us to add sufficient iodine to our food or water in order to be on the safe side. This is accomplished in the following manner:

By using iodized table salt.
By applying sodium iodide to the pint or so of water we drink each day.
By eating chocolate candy wafers containing iodine, or by iodizing the public water supply.

Three of these methods depend, of course, upon the action of the individual, while the last method is taken care of by those in charge of the public water supply, and all in the community receive the benefits therefrom.

Rochester, N. Y. seems to have been the pioneer in the iodizing of its public water supply. Both the water and health bureaus in that city have worked together on the problem with the result that they have been carrying on this treatment for several years. The results obtained have been encouraging and in a recent letter I had from Beekman C. Little, Superintendent of the Water Department

[1] Presented before the Montana Section meeting, April 17, 1926.

[2] Superintendent, Public Utility Departments, Anaconda Copper Manufacturing Co., Anaconda, Mont.

at Rochester, he tells me that Rochester has no idea of discontinuing the treatment.

In Anaconda the public water supply was first treated with sodium iodide in April, 1925. Another treatment was given in October, 1925, and our, 1926, spring treatment has just recently been completed.

Sodium iodide is applied for a period of 14 days in the spring and for the same period during the fall. The required amount of salt is applied each day in our reservoir (as is the case in Rochester) and we also feed by solution through one of our penstocks, thereby taking care of all of the water that enters our distribution system.

The iodide is applied on the basis of 0.664 pounds per million gallons consumption, which is the equivalent of 0.0003 gram per gallon of water.

The annual cost at Anaconda figures $600.00 or 5 cents per capita. This is somewhat higher than Rochester's cost of 3 cents per capita due to a higher per capita consumption at Anaconda.

While our treatments at Anaconda have not as yet proven that we are preventing simple goiter so common in children, we feel that after sufficient time has elapsed and more treatments are given, the figures submitted to us by the school and health authorities will show that simple goiter among school children is on the decrease as found in Rochester, New York, after several years of treatment.

The school officials at Anaconda report 6 per cent of the children as having simple goiter. This figure we hope to reduce.

Quite recently our school officials contracted for a supply of chocolate coated iodine tablets which they plan on giving to the children for 30 days during the school year, that is, 15 days in the spring and 15 days in the fall.

Each child (subject to the approval of its parents) will be given 30 tablets per year. These tablets contain 10 mgm. each or the equivalent of $\frac{1}{6}$ grain of iodine. Tablets are purchased at the rate of $275.00 per 100,000 and it is estimated that 2000 children will be treated in this manner. All treatments will be under the supervision of the health officials.

Sodium iodide costs $4.75 per pound f.o.b. Anaconda. There is very little trouble in applying it to our water supply and we believe (from all the data we have on the subject) that the dosage applied to our water supply is sufficient to ward off simple goiter.

ELECTRIFICATION OF THE LAFAYETTE, INDIANA, WATER SUPPLY[1]

By John W. Moore[2]

The principal business section of Lafayette is located on the low table land adjacent to the Wabash River. The city has gradually grown, however, until a large part of the residential district is located on the high table land and known as the Columbian Park section.

Many years ago two steam driven pumps each of 6,000,000 gallons daily displacement were installed in what is known as the Canal Street pumping station, pumping by suction from wells located in the channel of the Wabash River, serving the customers on the lower level of Lafayette. The surplus water from these pumps supplied a reservoir of four and one-half million gallons capacity and located at Columbian Park, therefore, furnishing adequate pressure at all times to the principal section on the lower levels of the city.

The upper level of Lafayette was served by a steam operated pump in the Columbian Park pumping station located adjacent to the reservoir. There being no elevated storage tank on the Columbian Park system it was necessary that this pump be operated continuously.

In 1912 the writer recommended that the city sink wells near the Canal Street pumping station and install an air lift pumping system. These wells and the air lift pumping system were installed, the water being delivered from the wells into a receiving basin constructed some forty feet in diameter and located on the same level and near to the Canal Street pumping station.

A short time after the steam driven air lift system was installed three of the wells were equipped with motor driven deep well pumps of the impeller type for the purpose, if possible, of reducing the cost of pumping.

[1] Presented before the Indiana Section meeting, March 26, 1926.

[2] Consulting Engineer, Indianapolis, Ind.

The steam driven pumps at Canal Street pumping station then pumped direct from the receiving basin and thereby were relieved of the high suction lift which gave much trouble when lifting from the wells located in the Wabash River.

The old steam driven pumps both at Columbian Park station and Canal Street station served the city for many years and so far as is known were models of equipment of that type.

The long service of these pumps, the increased demand for water by the city, and the improvement of modern pumping equipment, all demanded that these steam driven pumps be discarded and modern equipment installed.

In 1922 the members of the Board of Public Works of Lafayette found themselves confronted with a very serious problem in maintaining a dependable and sufficient water supply to meet the requirements of the city.

During the latter part of 1922 the writer was instructed to make a complete investigation and a report with recommendations on the entire water supply question. The report and recommendations were approved as submitted.

The conditions at Lafayette divide the problems into three distinct divisions.

1. The pumping of the water from wells to the existing receiving basin at Canal Street pumping station.

2. The pumping of the water from the basin at Canal Street pumping station into the mains serving the lower level of the city, the surplus supplying the reservoir at Columbian Park.

3. The pumping of the water by the Columbian Park station from the reservoir and into the distribution system serving Columbian Park and the upper level of the city.

DIVISION 1

There are fourteen wells, each 12 inches in diameter and approximately 100 feet in depth. These wells penetrate a very satisfactory water bearing gravel and each well has a capacity of from 1000 to 1300 gallons of water per minute. In five of these wells were installed modern motor driven deep well pumps, each having a capacity of 1000 gallons per minute. The three old impeller type pumps were discarded.

As an auxiliary or standby equipment for pumping the water from the wells a motor driven air compressor was installed at the Canal

Street pumping station to operate nine of the wells already equipped for pumping with air. The motor driving this air compressor is of the slip ring type receiving the current at 2200 volts. The use of the steam driven air compressor was discontinued.

DIVISION 2

At the Canal Street pumping station two pumping units were installed each having a capacity of 6 m.g.d. when pumping against 110 pounds pressure. These pumping units are of the two-stage centrifugal type and are driven by synchronous motors. These units have separate suction pipes from the receiving basin and separate discharge pipes to the mains. They are equipped with both vacuum and pressure gauges and flow meters. Motors receive the electric current at 2200 volts and are ample to meet any demand that may be required by the pumps which they drive under any condition of head.

DIVISION 3

The wide variation in demand at the Columbian Park station was met by installing duplicate motor driven centrifugal pumping units, each unit having a capacity of 1.5 m.g.d.

For fire protection there was installed one motor driven centrifugal pumping unit of 3 m.g.d. capacity.

The two domestic service pumps when in parallel will deliver 3 m.g.d. at 56 pounds pressure. If occasion should demand they can quickly be placed in series and will then deliver water at the rate of 1.5 m.g.d. at fire pressure, which when taken in connection with pumping unit for fire protection gives a total capacity at fire pressure at this Columbian Park station of 4.5 m.g.d.

A relief valve is set to take care of any excess pressure that may develop by the sudden closing of a fire hydrant at a time when fire pressure is being carried.

Certain efficiencies were required to be guaranteed by the manufacturers installing this equipment, an indemnity bond equal to the full amount of the bid being required to protect the city against the failure of the equipment to meet the guarantees when tested.

The overall efficiency of the deep well pumping units is 58.5 per cent.

The overall efficiency of each of the two pumping units of 6 m.g.d. pumping against 270 feet total head is 75.2 per cent.

Efficiency of each motor at 100 per cent power factor is 94.1 per cent.

The speed of the pump and motor is 1200 r.p.m.

If for any reason the pressure should be reduced against which these two units operate, the capacity of each unit will automatically increase as the pressure decreases to a maximum of 9 m.g.d. against 43 pounds pressure.

The overall efficiency on the air lift pumping system could not justly be required of the bidder furnishing the motor and air compressor. Therefore, the efficiency of the motor and the volumetric efficiency of the air compressor under the stated conditions only were required.

The guarantees on the 1.5 m.g.d. capacity pumping units for domestic service at Columbian Park station were as follows:

Speed of pump and motor, 1760 r.p.m.

Pump efficiency and b.h.p. at full capacity, 75 per cent and 45.7 b.h.p.

Pump efficiency and b.h.p. at 50 per cent capacity, 60 per cent and 32.5 b.h.p.

If for any reason the pressure should be reduced against which these two units operate the capacity of each unit would automatically increase as the pressure decreased to a maximum of 2 m.g.d. when pumping against 27 pounds pressure.

The guarantees required on the fire pump of 3 m.g.d. capacity at this station follows:

Speed of pump and motor, 1760 r.p.m.

The efficiency and b.h.p. at full capacity is 74 per cent and 185 b.h.p.

The pump efficiency and b.h.p. at 50 per cent capacity is 57 per cent and 140.7 b.h.p.

Actual tests were run on the operation of the motor driven compressor and air lift pumping system and on the old Hill-Tripp deep well impeller type pumps and on the new modern deep well pumps with the following results:

The cost of pumping water by the modern deep well pumps per thousand gallons equals $0.0062; by the old Hill-Tripp impeller type of pumps $0.0128; by the motor driven air lift pumping system $0.0104.

The level of the water in the wells at Lafayette is controlled largely by the stage of the Wabash River and the wide variation

affects the cost of operation of the air lift pumping system to such an extent that it is not advisable to use it except at such times as repairs are being made to the deep well pumps.

In 1922 the cost of operating by steam driven equipment at both stations equalled $72,832.03.

In 1925 the operation of the plant had been changed from steam to electric drive, except the steam driven air compressor. The pumpage in 1925 exceeded that of 1922 by 31 m.g. The cost of operation in 1925 under the above conditions was $63,945.86 or a saving of $8,888.

The complete change from steam to motor driven equipment has now been made and the saving in the cost of operation over the old steam plant is estimated to be a minimum of $12,000 each year.

The modern deep well pumps when delivering the full supply of water from the wells into the receiving basin show a saving in cost of about $4,000 each year over the same amount of water when pumped by means of the air lift pumping system, hence the reason for discontinuing the air lift in favor of the modern deep well pumps under the existing conditions at Lafayette.

The reason for installing a motor driven air compressor to operate the existing air lift pumping system is that the dependability of this system of pumping is much greater than any other known system of deep well pumping, due to there being no moving parts in the wells or electric wires required to each well so pumped.

The greatest amount of water pumped in any one day at the Canal Street pumping station is approximately 4 m.g. or about two-thirds of the minimum capacity of one of the large centrifugal pumping units at that station.

The total capacity of the well pumps and wells is 10.8 m.g.d.; of the two pumping units at the Canal Street station at high pressure is 12 m.g.d. and the maximum capacity against 43 pounds pressure is over 18 m.g.d.

The total capacity of the three pumps at the Columbian Park station for domestic service is 6 m.g.d. and at fire pressure is 4.5 m.g.d.

The location of Lafayette in reference to the super-power plants is such that the Indiana Board of Fire Underwriters did not require the installation of auxiliary power.

In addition to the large electric power plant located within a

few blocks of the Canal Street station which supplies the water works pumps through two power lines located on separate streets, power is available from the super-power plants located at South Bend, Dresser, Norway, and Oakdale. These plants are all interconnected and can give service within a very few minutes after the demand is made.

The maximum supply for Lafayette at this time is governed by the capacity of the wells and the deep well pumping system.

If the population of Lafayette is taken to be 24,000, then the wells and pumping units as now installed can deliver each twenty-four hours 450 gallons of water for each inhabitant.

PIPE LAYING METHODS[1]

By John W. Toyne[2]

No single line of activity in which the waterworks men are engaged is as universal as pipe laying, whether it be to serve such cities as greater New York, or London, or the village of some two or three hundred people. This is not only true now, but has been since the time of the ancient aqueducts, and will continue to be as long as man is human and gregarious. It cannot be otherwise, and any subject that is of interest to every man engaged in any given line of endeavor, regardless of whether he is the biggest, or the smallest, is worthy of consideration and discussion.

When one attempts to cover this field he is confronted with an almost endless combination of materials and conditions. The pipe may be steel, cast-iron, wood, concrete or stone, and under each of these classes are the two or more subdivisions; the steel may be hammer-weld, riveted, lock-bar or spiral. The cast-iron may be bell-and-spigot, either A. W. W. A. specifications or some modifications of it, flanged, tapered male and female, ball and socket or a combination of two or more of these. The wood may be either continuous or machine banded of any of several different woods, and steel, iron or alloy banding. Concrete, either monolithic poured in place, or precast, plain or reinforced of several designs of joints and types of reinforcement are used. Stone, thank heaven, is practically obsolete, except for open channels or pressure tunnels.

The soil and other local influences, such as availability, cost, labor conditions and requirements of the service enter largely into the selection of the pipe and also the method of its installation. The soil may be anything from quick-sand in aqueous suspension to solid granite, the labor, anything from "Mexican Breeds" to "Technical Graduates" and in the past twenty-five years I have had the pleasure of utilizing both extremes and every gradation between.

The service requirement may be anything from a gravity flow line, which might almost as well be an open channel, to a high pressure

[1] Presented before the Indiana Section meeting, March 26, 1926.

[2] Consulting Engineer, South Bend, Ind.

fire service. But whatever the soil conditions, whatever the labor, whatever the requirements of service, the waterworks man must accept them "as is," and the pipe must go into the ground.

In this section of the country by far the largest portion of the pipe installed for waterworks service is cast-iron, and more bell and spigot than all other types combined. Consequently, it is in this type that most of the waterworks men in this section are more vitally interested, and to this I shall devote most of my time.

One feature of pipe laying is common regardless of types, kinds and sizes of pipe. The trench must be opened and it must be backfilled. It is true, the methods employed in this vary with the conditions encountered, ranging from dry boxing to blasting, but in general the procedure follows very similar lines. It is only a few years ago that the pick and No. 2 were the generally recognized pieces of excavating machinery and "Dobbin" and a "slip" made a very modern backfiller. Today, the modern trench excavator, either the wheel, ladder or dipper type, is in common use and the selection of type depends on the soil conditions to be encountered. Equally, the mechanical backfiller has supplanted the horse and scraper. In both of these pieces of modern equipment the waterworks man has a fairly wide field of choice and so far as I am able to determine from experience and observation, all of several types have real merit, if used under conditions for which they were designed.

In equipping for this kind of work one must not overlook a trench pump or pumps as the conditions may require. The successor of the old bailing bucket is the gas engine driven trench pump, usually of the self-cleaning diaphragm type and mounted on trucks or wheels to facilitate moving to any point at which it may be needed without delay.

Probably more cast-iron pipe is laid with lead joints cast in the trench than in any other manner. For years this was practically the only method used; in recent years the tapered male and female metal to metal joint has been marketed under the trade name "Universal" and used with no little success, its advantages being speed in installing and freedom from the trouble experienced in trying to cast a lead joint in wet trenches. The pre-cast lead joint is meeting with considerable favor. This joint is made complete in the pipe plant and shipped to the consumer ready to install by simply inserting the spigot into the bell that carries the pre-cast joint, and then driving up the lead. In this connection I wonder how many

of you remember the pre-cast joint of a number of years ago, in which a tapered lead collar was cast around the spigot and driven into a tapered machined bell.

Sulphur-base jointing compounds have been growing in favor, especially in the past six or eight years Personally I have laid some fifty miles of cast-iron pipe, from 6 to 30 inches, using one of these compounds, Leadite, and have had excellent results. In using a jointing material of this character, it is absolutely essential that the pipe, both the bell and the spigot, be clean and free from oil or grease; that the temperature of the compound be just right and that a gate of sufficient height be used to make up the shrinkage which is much greater than in lead.

In reviewing pipe laying methods, one cannot fail to note the tendency toward the elimination of hand labor and the substitution of material and equipment to this end. This is in keeping with modern day practice in all lines and is largely responsible for the better working conditions, better returns and better results.

Before closing, there is one point I feel has not received the attention it deserves, namely, sterilization of the line. There was a time when any water was water, and anything that would carry that water to the consumer was a satisfactory distribution system. So far as water is concerned, that time is now history. We lay great stress on the suppression of that old land mark—the "Roller Towel" and the elimination of the "Community Tin-cup." We spend literally millions to safeguard our water supplies through filtration and disinfection, we go farther and soften the water to make it more attractive to our consumers, in some localities, even medicate it, and then drag our pipe through the mud and filth of the streets, handle it with men who, to say the least, are not surgically clean, lay it under conditions "as is," rinse it out with a little cold water and invite our customers to try a drink from it of our nice pure, softened water. In the light of modern day knowledge of effective and economical sterilization, isn't that an absurdity?

DISCUSSION

J. B. Marvin:[3] Expense tables innumerable are available, covering costs of laying all sizes of cast-iron pipe with lead joints—this being the standard class of material commonly used. The total costs vary with the fluctuating costs of material and labor.

[3] Consulting Engineer, Frankfort, Ind.

In certain earth formations and where rock does not lie too near the surface and the volume of work to be done warrants, a trenching machine can be used to great advantage.

I had an experience a few years ago with a trenching machine which was used in laying a 12 inch wood stave pipe line for a distance of nine miles. The topography was considerably broken but with many short stretches of table land. The trench was an average of 22 inches wide and 4 feet deep. A record was kept on 35,615 feet covering trenching and pipe laying which showed an average of 180 feet per hour. The greatest accomplishment in any day was 1750 feet in six and one-half hours for trenching and pipe laying. The trenching and pipe laying gang consisted of 6 men. As favorable results should be obtained in laying cast-iron pipe under as favorable conditions, plus the added cost required for laying cast-iron pipe.

An experience covering the last eight years in substituting Leadite for lead in laying cast iron pipe in 8 and 6 inch sizes with some 4 inch is favorable to the substitute.

Lower costs in construction occur without suffering harmful results in higher costs for maintenance. Lower costs accrue from the difference in the cost of material in the use of a substitute for lead in making joints in the laying of cast iron pipe.

An example is shown below from the book of personal experience in which a substitute for lead was used, the joints being made with Leadite.

Laid in 1918:

2304 feet 8-inch Class "B" Standard C. I. pipe
264 feet 6-inch Class "B" Standard C. I. pipe
218 feet 4-inch Class "B" Standard C. I. pipe

Used 1138 pounds of Leadite @ 12 cents	$136.56	
Used 68 pounds of hemp @ 35 cents	23.80	$160.36

If lead and oakum had been used at the prevailing cost of material at that time, allowing to the joint 8 pounds for the 4 inch, 11 pounds for the 6 inch, and 14 pounds for the 8 inch, the cost would have been:

3074 pounds lead @ 9 cents	$276.66	
80 pounds oakum @ 9 cents	7.20	$283.86
Difference in cost of material		$123.50
In addition there was a saving in labor on bell holes and calking amounting to about ¾ cent per foot		$20.89
Making a saving of		$144.39 or 52½ per cent

The pipe has been in constant use for eight years with pressure varying from 45 to 75 pounds and in that time there have developed six leaks—five minor which were repaired by caulking with lead wool and one where it was found advisable to make a new joint.

The cause of the leaks were not fully determined, but it is probable that they developed through porosity of the substitute which, no doubt, is the result of the Leadite being poured at an incorrect temperature. However, I find that a new fire pot has been developed, with thermostat attachment, that automatically regulates the temperature, and should obviate generally troubles of this nature and add to the satisfaction of using the substitute.

Perhaps there is a tendency to conservatism, holding fast to that which is in general use regardless of savings that may accrue by getting out of well beaten paths. In a small way, no doubt, it would matter but little, but if changes in any line of construction have demonstrated economical advantages, why not use it in the small as well as the large undertakings? If it adds to the efficiency of the one, it should prove worth while to the other.

DECREASING INDIANA'S FIRE LOSS[1]

By Clarence Goldsmith[2]

The subject of Indiana's fire loss deserves your careful study, as it does that of every citizen of the state; however, your duty along this line is more clearly defined as most of you occupy positions of public trust, and the curbing of the state's fire loss rests in a large measure on you.

Fire dissipated our accumulated national wealth in America during the year 1924 to the tune of $549,062,124, and during this same period the fire loss in your state amounted to $11,823,667. The problem, without question, merits all the thought which can be given it.

An eminent divine and educator has laid down five fundamental laws for effective thinking. The difference between effective and ineffective thinking is the difference between realistic and romantic thinking. Let us be responsible realists instead of irresponsible romanticists in handling this matter. In order that we may keep our method of attack constantly in mind and carry it through in an orderly manner, we will resort to "apt alliteration's artful aid" in handling the facts connected with the fire loss problem.

Find the facts
Focus the facts
Filter the facts
Face the facts
Follow the facts

The finding and assembling of all facts should be done without prejudice, and in this case it can be so done and with a considerable degree of accuracy. The Actuarial Bureau of The National Board of Fire Underwriters, at its main office in New York, receives the records of the fire losses paid in the United States. These are entered on punch record cards so that they can later be sorted by motor-

[1] Presented at the Indiana Section meeting, March 25, 1926.

[2] Assistant Chief Engineer, The National Board of Fire Underwriters, Chicago, Ill.

driven machines which assemble the cards of each state separately and further subdivide the cards so that the losses from the several causes of fires can be summarized. As the totals for any one year cannot be secured until all claims are paid and adjusted, it is not feasible to compile the data for any one year until about one year later; hence, the fire loss for the year 1924 is the latest for which accurate figures are available for the state.

The following are the six primary causes of fires which contributed the larger losses in the state during 1924:

Electricity	$987,057
Spontaneous combustion	859,411
Matches and smoking	809,464
Sparks on roofs	758,006
Stoves, furnaces, boilers, and their pipes	710,657
Defective chimneys and flues	589,971

In addition to these primary known causes, unknown causes resulted in a loss of $3,485,665, while exposure fires, including conflagrations, totaled $1,405,161.

It would be desirable to have one other basic fact in connection with the Indiana loss, but, unfortunately, this is not readily available; however, it can be approximated in the following way. During the year 1924 the number of fires in the United States for which claims were paid was 421,135. The total number of these fires in which the loss exceeded $10,000 was 5816. If the ratio between the national fire loss and the number of large fires be approximately correct for the State of Indiana, the number of fires in the state involving a loss of $10,000 and over during the year 1924 approximated 125, and the total loss from these large fires is estimated as 70 per cent of the entire fire loss in the state during that year.

We have now found these general facts and catalogued them. Our next step must be to focus the facts so that we can determine the issues which must be faced, and filter the facts, after examining them minutely so that our conclusions will not be warped by prejudice or selfish interest. With this in view, we will take up the individual causes of the larger losses.

Electricity is one of the greatest boons of the century to humanity, and there exists no safer form of light, heat, and power when it is properly installed and used. Regulations of The National Board of Fire Underwriters for Electric Wiring and Apparatus, known as the "National Electrical Code," compiled by thirty-three engineer-

ing, trades, and fire underwriters' organizations and approved by the American Engineering Standards Committee, provides for the safe installation of electric wiring and apparatus. Electrical appliances and equipment, suitable for all purposes, which have been inspected and listed by the Underwriters' Laboratories can be purchased. Their label signifies that the manufacturer has conformed in all essentials to the standards established by the Laboratories.

Spontaneous combustion, to which is ascribed the second largest loss, can be prevented by exercising due care in the storing and warehousing of materials which are subject to more or less rapid oxidation which may finally start a fire through spontaneous combustion.

The loss charged against matches and smoking is due almost entirely to carelessness. A carelessly tossed match that went through a broken glass deadlight in the basement of a mercantile establishment is believed to have caused the great Baltimore fire of 1904. Every year carelessly tossed matches and cigarettes run losses to the millions. All states, cities, and even many of the smaller towns have laws and ordinances regulating the handling and use of the more important hazardous materials, but it is not practicable to enact or enforce such ordinances to safeguard the use and disposal of such small things as a match and a cigarette butt.

Your state is fortunate that the loss due to sparks on roofs was not larger than that reported when the large number of shingled roofs is considered with their dry shingles standing on end as ready to perpetuate the fire contained in a stray spark as a tinder box. The menace of this hazard which makes conflagrations possible can be eliminated by the use of fire-resistive or fireproof roof coverings.

Heating devices, including stoves, furnaces, boilers, and their pipes, extracted their toll of nearly three-fourths of a million dollars, most of which was entirely unnecessary for most cities contain in their building codes regulations which provide for the safe installation of such equipment, and no mechanic or householder, even in the small town or rural district should attempt to install any heating device without ascertaining the safe method of doing it. This information can readily be obtained from the National Fire Protection Association whose suggestions on the subject are based on the best engineering advice and borne out by long and varied experience.

Defective chimneys and flues is the sixth cause in the order of the size of the fire loss in the state. Fire attributed to this cause can be entirely eliminated in new buildings provided the chimneys are con-

structed in accordance with the latest standards for chimney construction. Such standards are found in many municipal building codes, and are incorporated in the Department of Commerce's Elimination of Waste Series, entitled "Recommended Minimum Requirements for Small Dwelling Construction." Existing chimneys can and should be tested so that those which are flimsy and unlined, with wooden beams projecting into their walls, can be replaced. If the exposed outside surface of the chimney is at any time too hot to rest the hand against without discomfort, it is an indication that any woodwork in contact with it is in an unsafe condition. A smoke test is a simple method of detecting the presence of cracks or other openings in flues. The method is to build a smudge fire in the furnace or boiler connected to the bottom of the flue, and when the smoke is flowing freely, close it tightly at the top. The escape of smoke through the chimney walls or into other flues indicates defects which should be corrected. To ascertain if old chimneys need rebuilding, climb to the top and look down inside. If the mortar has fallen from between the bricks on the inside, it will soon do so all the way through the wall. Such chimneys should be rebuilt at once.

Unquestionably from one-half to three-fourths of the loss attributed to unknown causes could be eliminated by proper care and good housekeeping.

The loss due to exposure fires could be materially reduced by protecting the horizontal openings in buildings in closely built-up territory and by universal adoption of fire-resistive or fireproof roof coverings.

An analysis of the following causes which resulted in losses less than the six major individual causes should be carried out, and in each instance the remedy will be as patent as the remedies already cited:

Sparks from machinery
Sparks from combustion
Lightning
Petroleum and its products
Hot ashes, coal and open fires
Rubbish and litter

Having found the facts, and focused the facts, and filtered the facts in a general way, let us face the facts and map out a plan of campaign to follow the facts. Facts have a ruthless way of winning the day sooner or later. It is, therefore, a waste of energy to look for ways and means to get around, under, or over them, so let us save this energy by facing them frankly in the beginning.

Fire Underwriters make various estimates of the percentage of the number of fires and the percentage of monetary fire loss which are strictly preventable. Their opinions are also more or less at wide variance in regard to the water and smoke damage incidental to fires and their extinguishment. Inasmuch as it is impossible to accurately determine these facts, no time should be wasted in arguing them. We do know that a considerable percentage of fires and the loss due to them can be prevented, so let us consider the means at hand to solve the problem.

In the early seventies, immediately after Boston's great fire, the members of The National Board of Fire Underwriters had a dawning consciousness of the importance of fire prevention, and this consciousness has resulted in the Board's becoming the leading factor in fire prevention and leading to its activities as a public service institution as well as a business association.

In 1896 a group of technically educated men in the ranks of the stock fire insurance companies, stimulated by the object lesson of the Mutual Fire Insurance Companies, formed an organization with the prevention of fires as its exclusive purpose, and thus the National Fire Protection Association was born and now has a total membership of over four thousand.

The United States Chamber of Commerce has for the past several years conducted Interchamber Fire Waste Contests in many large cities which have resulted in a very definite reduction in the fire losses of these cities. The Chamber is also affiliated with the National Fire Waste Council.

These organizations are prepared to help the local organizations in the State of Indiana in an advisory way in dealing with the problem, as is also the Fire Prevention Department of the Western Actuarial Bureau, which covers the Middle-West.

The actual work of offense and defense must necessarily be carried on by organizations within the state, and such organizations are already in existence and have been functioning with as marked effect as similar organizations in other states. Nevertheless, the facts show that their work must receive a further impetus by an increased support of the citizens of the state, for the record of the annual fire loss in the state is as follows:

1920	$9,924,177
1921	8,548,019
1922	8,490,716

1923	$ 9,293,554
1924	11,823,667

In considering these figures it must be borne in mind that they represent the actual losses paid by fire insurance companies, and not the actual losses in the state, for uninsured and unreported losses are probably sufficient to increase these figures by almost twenty-five per cent.

The Fire Marshal Law has been in force in Indiana since 1913. The Fire Marshal's Department is organized in two main divisions, one for handling all matters growing out of incendiary or suspected incendiary fires, and a second for inspections and enforcement of civil regulations. The present Fire Marshal, Alfred M. Hogston, directs all activities, having a Deputy Fire Marshal in charge of each division, with a corps of competent investigators assigned to the Arson Division, and a corps of trained inspectors assigned to duty in the Inspection Division. The state has been fortunate, not only in the selection of the present Fire Marshal, but in his predecessors, and the work accomplished by the department is worthy of exceptional credit. The fire chiefs in all cities and towns are made Assistant Fire Marshals by virtue of the Fire Marshal Law, thus making a large and strong organization backed by state authority.

The larger cities have more or less complete fire prevention ordinances, and even the smaller cities and towns are gradually adopting such ordinances. The enforcement of these ordinances is vested either in a fire prevention bureau forming a part of the fire department, or directly with the fire chief. The state is, therefore, provided with the proper governmental machinery to face the facts and to follow the facts.

Support is given to the fire prevention movement by chambers of commerce and other civic organizations, as well as by the Indiana State Fire Prevention Association, the latter being composed of fire insurance agents who periodically assemble in the several cities of the state and make inspections of property, thus giving the owners the benefit of their knowledge. Hearty support is given to the fire prevention movement by the press and the public schools.

There must be some way for all of these organizations that are devoting the earnest endeavors of their membership to the reduction of the fire loss to produce greater results than they have in times past. Without question, the education of the citizens of the state along fire prevention lines should be continued along even broader lines

than has been carried out in the past. If particular attention is given to teaching the fundamentals in our schools, in a relatively few years, the entire population will be acquainted with the axioms and principles, which, if carried out, cannot fail to reduce the number of fires.

There is one important point, however, which must not be lost sight of, for when we focused and filtered the facts, it was found that about seventy per cent of the entire fire loss was due to about twenty per cent of the total number of fires, which should readily lead to the conclusion that our energies should be concentrated on the prevention and extinguishment of fires in properties where high values prevail.

Even when the fire prevention idea is universally recognized and appreciated, fires will still occur, although in decreasing numbers. The loss from these fires will be dependent upon the structural design of the buildings, the fire extinguishing equipment available, and the methods of operating this equipment, together with the efficiency with which salvage operations are performed. It is not humanly possible for our best fire departments to cope with a fire which has obtained any considerable headway in a faultily constructed building which has neither its floor openings nor window openings protected.

In order that the losses due to unavoidable fires may be kept at a reasonable minimum, consideration must be given to restricting the fire areas so that only moderate values may be involved in a single fire. This can be economically done by subdividing excessive areas by fire walls, and if it is necessary to have intercommunication between these areas, the openings in the fire walls should be equipped with standard fire doors. With standard protection on all floor openings and wall openings, it will then be possible for fire departments to confine the fire in the area of origin if reasonably adequate fire-fighting facilities are provided.

All fires which result in individual large losses do not occur in the mercantile and manufacturing districts of our larger cities. The fire losses on farm properties run into the millions, and a larger proportion of fires originating on farms result in total losses than in cities and towns because fire-fighting equipment is not available to control them. Defective chimneys and flues and lightning are the causes which produce the greater number of losses. The first cause can be eliminated by the proper construction and maintenance of chimneys, and the loss from the second cause can be materially re-

duced by the installation of lightning rods. Those residing in rural districts should learn the principal causes of the origin of fire and guard against them by exercising due care.

The American Water Works Association has already formed a Fire Protection Division which is coöperating with a similar division of the International Association of Fire Engineers and with the National Fire Protection Association. The coördination of effort of these three organizations within the last two years has been a distinct step toward the reduction of the fire loss.

During the past decade those in charge of the design, construction, and operation of water works have realized more fully their responsibility for furnishing water for fire extinguishment. Studies have been made of the carrying capacities of distribution systems and weak points have been strengthened. Old hydrants have been replaced, and modern pumping equipment has been installed in place of that which had become obsolete. In making these improvements the fire department officials have been consulted, and many water departments are today dispatching employes to the fire grounds upon receipt of alarms to cooperate with fire departments. Fire chiefs have shown an increasing desire to cooperate with the water departments by advising where larger quantities of water are required on account of excessive hazards, where additional hydrants are needed, and where deficiencies are found in the water supply during the fighting of fires. Our fire departments should receive the fullest support of all fire prevention organizations in order that sufficient funds may be provided to properly man the apparatus, for it is false economy for a department to be handicapped in the use of its expensive and effective equipment by the lack of men to operate it.

When it is realized that a large portion of the fire loss is due to water damage to those portions of the goods and buildings which have not been actually destroyed by fire, it must be conceded that salvage operations assume an equal importance with fire extinguishment. Since water is and must remain—how long no one knows—the chief extinguishing agent, much of this loss is unavoidable, but a very considerable saving can be made if suitable measures are taken during the progress of the fire to cover the contents with waterproof covers and dispose of all water as soon as the fire is extinguished. The burden of the fire loss rests upon the public, and for this reason, any reduction in it which can be made through salvage work by the fire department will result in lightening this burden. Many municipal

fire departments now carry waterproof covers, and are giving this particular phase of the problem more and more consideration.

Having found the facts, focused the facts, and filtered the facts, it is evident that to face the facts, and follow the facts, we must work toward a unity of action of the existing organizations that are laboring for a reduction of fire loss so that they may achieve their aims.

Secretary Wentworth, of the National Fire Protection Association, several years ago likened the efforts of each of the vast army of men and women interested in the cause of fire prevention to a snowflake, and then visualized a transcontinental train speeding westward and meeting a snowstorm. At first the flakes of snow appeared to offer little, if any, resistance to the passage of the train, but as the flakes fell throughout the night they gathered to such a depth that its progress was finally arrested. Let us simulate the snowstorm in our attack on the fire loss in the State of Indiana and it will be brought under control exactly as the powerful locomotive drawing the train was stopped.

THE IODINE CONTENT OF PENNSYLVANIA WATER SUPPLIES

By Francis E. Daniels[1]

From the numerous investigations and surveys concerning the prevalence of goiter, it seems to be the consensus of opinion among authorities that the disease is due to lack of assimilation of iodine. That there should be many individuals in any one community so afflicted, a deficiency in the iodine content of the food and drink of that community must exist. Except in more or less isolated districts, where all food and drink is obtained locally, it is rather difficult to keep track of the many sources of iodine available to the individuals. The foods of a cosmopolitan population vary exceedingly. In addition to those produced locally at certain seasons, many foods are obtained from all quarters of the country at all seasons of the year. Then again the subsistence varies extremely with the nationality and habits of both the rich and poorer classes.

Not only do different classes of food stuffs vary in iodine content, but one kind of food produced in one part of the country may have a very different amount of iodine from the same kind produced in another. Several publications giving the iodine content of food stuffs, both terrestrial and marine, have appeared and to some of these reference will be made later.

Inasmuch as the source of the public water supply of a community is considerably more constant than the food supply and as the public water is universally used, it has been endeavored to show that there is a relation between the iodine content of the water supply and the status of goiter in that community. Dr. J. F. McClendon of the University of Minnesota has made a wide survey throughout the United States and has published results of analyses of waters, which range from 0.01 to 184.7 parts per billion of iodine. Having taken into account the statistics of goiter, he classes all waters below 0.23 part per billion as iodine-poor and those having 0.23 part per billion or over as iodine-rich.

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As the health departments of several states have also made surveys on this subject, notably, Michigan, New Jersey and Utah, it was deemed wise to make observations on some of the public water supplies of Pennsylvania for comparison. For lack of funds a state wide survey could not be attempted, and only a few supplies were selected which, from their character and location, were believed would represent fairly well the conditions throughout the State. Had it not been for the very generous coöperation of the executives and chemists of the supplies selected, this survey would not have been possible.

With the exception of four supplies collected by our own representatives, the local superintendent or chemist concentrated the amount of water necessary for analysis and shipped the concentrate to our laboratory in one of our regular chemical water containers. This was a great convenience, as it made it possible to evaporate the samples simultaneously as well as save the transportation on samples of over 26 gallons each and the large empty container. For this coöperation we are deeply indebted.

There were available numerous methods for the determination of iodine in waters, but for various reasons they were discarded one by one until two were left. These were the method of M. J. Dubief as modified, used and published by the laboratory of the Michigan Department of Health, and the method of Doctor McClendon of the University of Minnesota.

Although the Michigan method was subject to some criticism as to its accuracy, it was adopted because of its being less expensive and taking less water. Having no idea of what results to expect we lost all of our samples before we were fully convinced that the method was unsuited to our Pennsylvania conditions.

We then decided to try out the method of Dr. McClendon, and accordingly asked our coöperators for another concentrated sample. We immediately began to get results, and although our figures may be a little low on account of the many chances for slight losses in the process, we believe they are substantially correct and sufficiently accurate for a single sample. For an extended survey, frequent samples should be taken under varying conditions throughout the year.

In a private communication F. E. Hale of the Mt. Prospect Laboratory, Brooklyn, N. Y., gave us some valuable suggestions and we

finally modified and used the method of iodine determination as follows:

METHOD OF DETERMINING IODINE

Boil the water in a large evaporating dish with sufficient sodium carbonate to keep the contents alkaline, adding measured quantities of water until 100 litres have been concentrated to about 400 cc.

Filter and transfer the filtrate to a 6-inch porcelain evaporating dish and concentrate to about 100 cc.

Filter again and evaporate the filtrate to dryness with frequent stirring to hasten the process and prevent caking.

Grind the residue in the porcelain dish with an agate pestle and reduce the solids to a dry powder by alternately grinding and drying in the oven.

Carefully scrape out and transfer the dry powder to a nickel boat and place the boat in a pyrex combustion tube 18 inches long by 1 inch in diameter, closed at one end and with a ¼-inch pyrex side tube at right angles near the closed end.

Clamp the combustion tube in a horizontal position with the side tube projecting downward into a test tube one-half full of N/10NaOH as a trap to catch any volatile iodine compounds.

Connect the combustion tube with a tank of oxygen and pass oxygen through at a rate of three or four bubbles a second.

Carefully heat the tube and boat with a Meeker burner, avoiding fusion of the solids, until the organic matter is burned leaving the residue white or somewhat gray.

Cool and wash the residue into a small beaker and break up the lumps.

With the NaOH from the trap, rinse the tube and evaporating dish from which the powder had been scraped, concentrate, transfer to the boat and evaporate to dryness and ignite as before with another portion of NaOH in the trap.

Rinse the tube again and add rinsings and second residue to the first in the small beaker.

Boil and filter.

Neutralize with sulphuric acid to approximately pH 6.6 using Phenol Red paper as indicator, and concentrate to a volume somewhat below 20 cc. and remove the salts which separate out.

Transfer to a 30 cc. separatory funnel and neutralize further with H_2SO_4 to about pH 3 using Brom-phenol-blue paper as indicator.

Add one drop N/10 arsenious acid, shake and allow to stand one-half hour.

Add 1 cc. pure CS_2 and one drop nitrosyl sulphuric acid and shake violently for two minutes.

Transfer the colored CS_2 to a small cup of a B & L Dubosc colorimeter and compare with a standard made in exactly the same manner from a carefully prepared solution of KI.

Make a second or third extraction with CS_2 and nitrosyl, if necessary, to remove all the iodine from the sample and make the necessary correction.

Report in parts per billion of iodine.

1. The water must be kept alkaline throughout the process of concentra-

tion, so the amount of Na_2CO_3 necessary will vary with the character of the sample.

2. The evaporation may be done in any large vessel and any convenient scheme may be employed to supply additional water as it boils away.

3. Frequent removal of the solids as they accumulate usually hastens the concentration.

4. A Buchner funnel with a suction pump was found to be exceedingly useful for rapid filtration. A gooch crucible can be used for the small volumes.

5. Frequent attention given to stirring, grinding and drying saves much time in the preparation of the residue.

6. With a blast lamp by using a little oxygen, an excellent combustion tube can be made by taking a piece of stock pyrex tubing 1 inch in diameter and 18 inches long, sealing one end, blowing a small hole in the side near the closed end and sealing in a short piece of ¼-inch pyrex tubing.

7. Oxygen may be obtained compressed in a tank or a small quantity made from potassium chlorate and manganese dioxide and used from an aspirator bottle.

8. A bent sheet of metal may be used for the combustion instead of a regular boat.

9. The reason for the second ignition is that, in most cases, organic fumes condense on the sides and unless collected and burned the accuracy of the determination is affected.

10. The indicator papers are made by soaking filter paper with the ordinary pH indicator solutions of Phenol Red and Brom-phenol-blue. The papers are then dried and cut into small bits. A few of these are put on a clean sheet of paper and touched with the moist end of the stirring rod. The end points are indicated by a yellow color.

11. For uniformity the volumes are kept close to 20 cc. and all salts which separate out are removed or else they give trouble in the CS_2 and stopcock.

12. Arsenious acid is added to reduce to iodides any iodates which may be present.

13. Nitrosyl-sulphuric acid is conveniently made by saturating a few cubic centimeters of strong H_2SO_4 with the oxides of nitrogen evolved from the action of dilute (1:1) nitric acid on copper.

14. The cups of the colorimeter measure 7 mm. internal diameter with plungers 5 mm. diameter. One cubic centimeter gives a working column of approximately 25 mm. By the use of the vernier scales a large range of values can be read with one standard.

15. Good results can also be obtained without a colorimeter by comparing the unknown with a series of standards placed in small vials of exactly the same internal diameter. This can be best determined by placing in a number of vials the same quantity of water and then selecting those whose columns are the same height.

16. The standards are made by treating a solution of KI containing the proper amount in a volume of 20 cc. with N/10 arsenious acid, nitrosyl and CS_2 in exactly the same manner as the unknown, although in practice we did not find the treatment with arsenious acid necessary and if another standard was wanted quickly a half hour's time was saved.

17. In making a second or third extraction unless all the extractions are mixed and read together, the later extractions may be over colored by some of the previous CS_2 remaining in the funnel.

18. Some chemists prefer to make the extractions of unknown and standards in stoppered test-tubes, and making the comparisons by holding them in an inclined position over a white surface.

The results of single samples from each supply collected for the most part during the winter months of 1924–25 are shown in table 1.

The 0 in the Beaver result means that the amount of iodine in 100 litres of water was too small to be measured by our method.

We were promised samples from Crum Creek and Neshaminy Falls near Philadelphia, from Easton and from DuBois and Brockwayville, but these samples failed to arrive.

In table 1 the results are arranged from east to west across the State and while most are from surface sources, some are from deep wells.

It will be noted that there is a considerable variation in the amount of iodine present and there also seems to be little or no geographic distribution. This would indicate practically no influence of the sea, and it is possible that the sources of our highest figures are from deep strata in the soil.

It must also be borne in mind that our big rivers are made up from the runoff of large inland territories.

Supplementing the foregoing we may include in table 2 Dr. McClendon's published iodine content of some food stuffs from both goitrous and non-goitrous regions, and in table 3 the iodine content of some sea foods, as published by the United States Bureau of Fisheries.

From the foregoing the United States Bureau of Fisheries has drawn and published the following conclusions:

. . . . There can be no doubt that iodine is to be found in all fish and fishery products, mollusks, and crustaceans. Moreover, it has been clearly shown that marine fish and shellfish contain much more iodine than fresh water fishes.

The data indicate that marine fishes, mollusks, and crustaceans contain a higher percentage of iodine than any other common foods. Oysters, clams, and lobsters contain more iodine than any other marine food, with the exception of marine algae, which, unfortunately, does not enter into the dietary of many Americans. As a matter of comparison, it is shown that oysters, clams, and lobsters contain about 200 times as much iodine as milk, eggs, or beefsteak; shrimp 100 times as much; and crabs and most ocean fishes 50 times as much. In order of decreasing iodine content the more common foodstuffs are divided into the following groups: (1) Marine algae, (2) oysters, clams, and lobsters,

(3) shrimp, (4) crabs and most ocean fishes, (5) freshwater fishes, vegetables, beefsteak, milk, etc.

It is evident that by using marine fish or shellfish in the diet two or three times each week the amount of iodine ingested could be increased considerably.

TABLE 1

Iodine content of some Pennsylvania waters

PUBLIC WATER SUPPLY	SOURCE OF WATER	IODINE IN PARTS PER BILLION
Philadelphia	Schuylkill River	0.1
Chester	Delaware River	1.5
Pickering Creek	Surface stream	1.1
Bethlehem	Wells & Lehigh River	2.5
Allentown	Wells	2.4
Scranton	Surface streams	1.5
Reading	Surface streams	1.5
Lancaster	Surface stream	1.2
Danville State Hospital	Susquehanna River	0.6
York	Surface stream	0.8
Hummelstown	Surface stream	1.4
Sunbury	Surface stream	0.6
Lewisburg	Surface stream	2.0
Harrisburg	Susquehanna River	0.5
Carlisle	Surface stream	0.5
Gettysburg	Surface stream	0.6
Johnstown	Surface stream	0.3
Warren State Hospital	Wells	2.5
Kittanning	Springs	0.6
Kittanning	Surface stream	0.5
McKees Rocks	Wells	1.0
South Pittsburgh	Monongahela River	0.5
Erie	Lake Erie	0.6
Meadville	Wells	1.7
New Brighton	Beaver River	0.2
Beaver	Wells	0.0
Monacca	Crib, Ohio River	0.1
Alliquippa	Wells	0.3
Ellwood City	Surface stream	1.1
Zelienople	Surface stream	6.0
Sharon	Shenango River	0.4

These facts should be of interest to the American people, expecially to those living in the so-called goiterous belts in which the iodine content of the water and foods is below normal. This is important in planning the diet of young people living in districts where disorders of thyroid gland are common.

TABLE 2

Milligrams of iodine per 1000 kilograms of dry foodstuff

	IODINE CONTENT	LOCALITY
Fron nongoitrous regions		
Wheat	4.0	Storrs, Conn.
Wheat	9.3	Edgecomb, Me.
Oats	23.0	Storrs, Conn.
Oats	175.0	Wiscosset, Me.
Corn	52.0	Wiscosset, Me.
Barley	73.0	Storrs, Conn.
Rye	3.5	Storrs, Conn.
Carrots	170.0	California Coast
Salmon	45.0	Alaska
Salmon	75.0	Oregon
Salmon	115.0	Alaska
Salmon	324.0	Alaska
Goat's milk	400.00	California Coast (Salinas)
From goitrous regions		
Cereals:		
Oats	10.0	Minnesota
Wheat	1.0	Minnesota
Wheat	6.6	Minnesota
Straight flour	3.5	Minnesota
Bran	15.5	Minnesota
Shorts	9.6	Minnesota
Red Dog	3.7	Minnesota
Pot herbs:		
Spinach	19.5	Oregon
String beans	29.0	Oregon
Carrots	2.3	Oregon
Soup vegetables	13.5	Oregon
Fruits:		
Apples (peeled and cored)	3.0	Oregon
Pears (peeled and cored)	15.0	Oregon
Prunes	4.8	Oregon
Bing cherries	33.0	Oregon
Peaches	11.1	Oregon
Loganberries	160.0	Oregon
Animal Foods:		
Skim milk	12.0	Minnesota
Butter	140.0	Minnesota

TABLE 3

Iodine content of sea foods; milligrams of iodine per kilogram of fresh substance

Mollusks:	
Clams, hard	1.37
Oysters	1.16
Scallops, giant	0.15
Crustaceans:	
Crabs, blue	
Soft, whole	0.09
Meat fllakes	0.18
Lobster	1.38
Shrimp	0.45
Marine fish:	
Bluefish	0.26
Cod	0.24
Haddock	0.29
Halibut	0.25
Mackeral	
Common	0.14
Spanish	0.40
Pollock	0.12
Pompano	0.08
Scup	0.30
Spot	0.59
Spotted	0.02
Squeteague	0.23
Tautog	0.27
Winter flounder	0.18
Anadromous fishes:	
Alewives	0.26
Rock	0.45
Smelt	0.01
White perch	0.42
Fresh-water fishes from Lake Erie:	
Cisco, smoked	0.24
Cisco roe, smoked	0.27
Lake trout	0.01
Whitefish	0.03
Fresh-water fishes from the Potomac River:	
Bass, largemouth black	0.05
Perch, yellow	0.02
Pickerel, eastern	0.07

TABLE 3—*Concluded*

Fresh-water fishes from the Mississippi River at Fairport, Iowa:	
Bass, largemouth black	0.01
Black bullhead	0.01
Bluegill	0.04
Bowfin	0.02
Buffalo fish:	
Bigmouth	0.02
Razorback	0.02
Carp	0.01
Carp sucker	0.03
Channel catfish	0.01
Car pike	0.01
Gizzard shad	0.01
White crappie	0.01

Accurate statistics concerning the prevalence of goiter in the localities mentioned are not available, but from general information it would seem impossible to establish any direct relation between the goiter and the iodine-content of the public water supply so as to use the latter as a definite index of the former. We believe that the discussions set forth in our preceding paragraphs are amply sufficient to account for this in the State of Pennsylvania.

The population is quite varied as to habits, customs and social conditions, and there are relatively few districts in which the subsistence of the population is not affected by outside influences.

According to authority if no other source of iodine were available, one would have to drink a quart of water from the Susquehanna River every day for two hundred and fifteen years to furnish sufficient iodine for a normal thyroid gland.

It is, therefore, hardly possible in Pennsylvania that, of itself, the iodine-content of the public water supplies can be more than even a very remote and indirect index of goiter.

The above work was done in Chemical Laboratory of the Bureau of Engineering of the Pennsylvania Department of Health, December 1924 to May 1925, under instructions from Dr. Charles H. Miner, Secretary of Health and W. L. Stevenson, Chief of the Bureau.

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EARLY EXAMINATION OF WATER SUPPLY IN COLORADO[1]

By William C. Mitchell[2]

One of the most important functions of a Board of Health is the investigation of the water supply or supplies used by individuals or a community for domestic purposes, the object of the investigation being to correct any factors of sanitary error which may be discovered.

In the wisely ruled events of her kingdom, Nature has made it possible, as it were, for cycles to be established in the perpetuation of her various phenomena. Thus, it is well known that the animal world is dependent for its existence on plant life, and it has created no surprise that generation after generation of endless species of animals have propagated themselves through all the centuries at the expense of growing vegetation. But what of vegetation itself? Since plants are referred to the soil for all but one of the elements on which they subsist, had not the generous lap of Mother Nature been long since exhausted of these elements? This, without doubt, would have been the case were it not that Nature causes those elements which are so inextricably bound up in the dead bodies of plants and animals to be reduced to their simpler elements and incorporated in the soil, so that in their turn they may be used anew in the upbuilding of plant life.

Bacteria are not only the indispensable agents, but are the only agents which make possible this alternate cycle of food assimilation, first by animals and then by plants in endless repetition.

Nature's great method of purifying water is likewise of a cyclic nature.

All of the waters of the earth's surface, that are exposed to the heat rays of the sun, are caused to evaporate to a greater or less degree. One hundred eighty-six thousand two hundred and forty cubic miles of water are estimated to be evaporated annually in this manner.

[1] Presented before the Conference of Water Superintendents and Sanitary Engineers of Wyoming, Colorado and New Mexico, February 23, 1926.

[2] Bacteriologist, State Board of Health, Denver, Colo.

This evaporated moisture coming in contact with the cold high atmosphere or blasts from the colder zones is precipitated as rain.

In fact, as we are taught in physics, the water of the earth may be compared to an immense boiler (about 145,000,000 square miles, or three-fourths of the surface of the earth being water), the radiant rays of the sun to the heat of a furnace, and the atmosphere to a still. Thus, in continual cycles, a beneficent nature is showering us with purified water. Unfortunately, this purified water is contaminated almost as soon as it comes in contact with the habitation of man or animals.

The storage of water in ponds, lakes, reservoirs and dams, and the so-called "self-purification" of waters in running streams, are uncertain and unreliable methods of purification. Next to rain water, nature's greatest ally is the biologic and physical action of the air and the soil of the earth's surface in prolonged contact with water, thus reducing the organic contents and destroying to a greater or less degree the living matter present.

In the year 1896, when the writer came to Denver, the typhoid death rate in the city of Denver was about 58 per 100,000, and had been very much higher than that. There was practically no bacteriological purification of the water supply—the so-called mechanical filters being entirely inadequate, as repeated bacteriological tests conclusively showed. The writer was engaged by the city of Denver to examine the Denver water supply, and systematic examinations were made almost daily for several years. When one considers the water-sheds from which the most of the water supply of Denver was drawn, they can be likened to the sides of irregular funnels, with a scant amount of soil on a rocky bottom, which facilitated the flow of water to the bottom of the funnel and incidentally causes a concentration of any contamination on the watershed.

In 1903, the Denver Union Water Company adopted the slow sand method of filtration, a policy which was frequently and urgently suggested by the writer to the late Walter Scott Cheesman, president of the company. To the improvement in slow sand filtration was added the use of copper sulphate solution to destroy algae and other fungi. Later, the water was treated with calcium hypochlorite; still later by liquid chlorine. Each of these sanitary improvements resulted in a consistent lowering of the typhoid death rate, until today, Denver has a typhoid death rate averaging in the past six years between 4 and 6 per 100,000.

As most interesting expositions of the manner in which epidemics of typhoid fever originate, I will quote briefly two epidemics which were investigated by me for the State Board of Health, in the early days of this work.

In the year 1900, an epidemic of typhoid fever of considerable magnitude occurred in Fort Collins. At that time, Fort Collins had a population of approximately 7,000. A few cases of typhoid had occurred from time to time during the year, as occurred also in other communities of Colorado, when suddenly, about the end of November, 1900, case after case of typhoid occurred in Fort Collins, until an estimated number of 200 cases of typhoid were reported, all occurring in the space of from two to three weeks.

An investigation of the watershed of the Cache la Poudre river showed the same to be open and free to any and all contamination which either the permanent residents or passing tourists or campers might see fit to deposit in the stream or on the banks. While the ordinary run of such pollution might account for the occasional cases of typhoid fever, it would take something definite to account for the epidemic.

A close scrutiny of the watershed revealed that in the little town of Bellvue, about two miles above the intake of the Fort Collins water supply, there had been five undoubted cases of typhoid fever. It was learned that in one of these cases, the doctor in charge gave orders that the discharges be disinfected with chloride of lime and buried. Instead of complying with these orders, the discharges were emptied into a little ditch which flowed past the house, so that they might be carried away. This little house ditch flowed into a larger ditch, and after running about one-eighth of a mile, joined the Poudre, as above stated, two miles from the intake of the city water supply. Thus, we have definite knowledge of typhoid stools emptying into the city supply on the third of November. The epidemic began November 19, 1900, and continued with two hundred cases coming down in rapid succession.

The writer has personal knowledge of tourists staying but a day or two in Fort Collins and coming down with typhoid in a week or two after leaving the city. Of course they drank the city water while there.

The manner of typhoid spread in the case of Fort Collins, might be called the "classic" method.

Many other epidemics of similar nature were investigated in the

state and an exacting survey of conditions on the watershed revealed without exception, the relation between deposited typhoid infection and its conveyal to the populace by water. An epidemic occurring at Leadville in the latter part of the year 1903, while it was conveyed by water as usual, yet the method of its conveyal occurred in an entirely different manner. A conservative estimate of the number of cases of typhoid was five hundred.

A most careful and painstaking examination of the various watersheds in and around Leadville, failed to reveal a single case of sickness of any kind. The sheds were also free of animal corrals, cesspools, etc.

The repeated examination of the water, both chemical and bacteriological, showed it to be of exceptional purity. The dairies were carefully inspected and no blame could be placed on them. We had the anomalous condition of pure water and pure milk and sanitarily correct watersheds—oysters, fresh vegetables and flies could also be excluded—and yet on the other hand, case after case of typhoid fever, occurring in such numbers that one was inevitably led to the conclusion that only a common vehicle could be the carrier of the contagion to so many people at one time, and that that vehicle was water.

In making a plot of the houses and streets where the cases of typhoid occurred, I was struck by the fact that certain blocks and streets were practically free from typhoid, while other blocks or streets would be filled with cases of sickness. Later, it was learned from Mr. West, superintendent of the Leadville Water Company, that the water mains of the city very frequently cracked and broke, due to the tunnels and stopes of the various mines running under the city. In the winter months, scarcely a week went by without repairs being made to these mains.

It was found that there were cases of typhoid fever in St. Vincent's Hospital, on a very high point of ground. The discharges from these cases went into a cesspool and from there, seeping their course downward through the town and toward the Arkansas River, unquestionably flowed along the outside of the water mains of the city. As long as pressure was on the mains, all was well, but when the pipes were drained to make the necessary repairs, this sewage was sucked into the pipes. From there it ran directly into the faucets of the houses when the pressure was turned on again.

In the vast majority of cases, the areas where the typhoid occurred

corresponded to the points at which the mains were drained and repaired. Other cases of typhoid can be accounted for by the carrying of the typhoid infection a long distance in the mains or by an infection of other mains under similar conditions, or by the fact that people may live in one section of the city and drink water in another section, as is often the case. The time also corresponded—there were at least three cases of typhoid in the hospital in the middle and later part of November, and the cases of typhoid appeared in epidemic proportion the first week in December.

Disinfection of the stools and cesspools and the correction of the sewerage system promptly abated the epidemic.

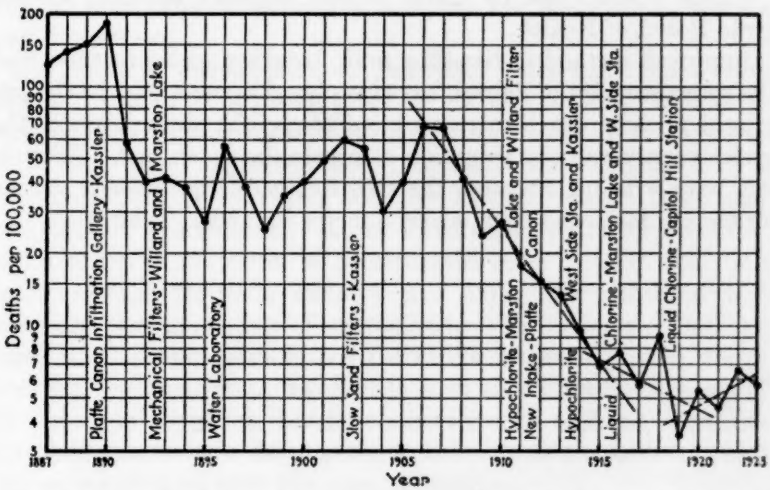

FIG. 1. TYPHOID FEVER DEATH RATE, DENVER, COLORADO. EFFECT OF IMPORTANT CHANGES IN WATER SUPPLY

In all of the epidemics studied for the State Board of Health, while a bacteriologic examination was always made and generally a chemical one, in no single instance could the origin of the epidemic have been traced *without a sanitary inspection.* This is the indispensable factor in such investigations, and will continue to be so until we have a reliable method of detecting the typhoid bacillus in water.

From time to time in communities supplied with pure drinking water, sporadic or limited epidemics of typhoid fever will occur, and these can usually be traced to a certain milk supply, but it should be remembered that even here contaminated water, as a rule, is at fault.

It was extremely difficult, even so recently as twenty-five years

ago, to make the laity believe that typhoid fever was conveyed by water, and, indeed, the medical profession was not always a unity on the subject. Opposition was often encountered in an attempt to obtain new water supplies or to better those already existing.

Fortunately, this opposition has practically vanished and in the onward march of progress, sanitary science has scored another victory.

A graph of the typhoid fever death rate in Denver for twenty-three years is shown in figure 1. Slow sand filters, were placed in operation in 1903. Hypochlorite was introduced in 1911 and liquid chlorine in 1916.

Figure 1 was made by Dana Kepner, sanitary engineer for the State Board of Health.

Improved method of handling milk, together with supervision of the water supplies of dairies, has also played a small part in the improved typhoid death rate—as has likewise the supervision of the oyster supply and the irrigation of vegetables eaten raw. Flies we still have with us, although the substitution of the gasoline station for the old fashioned barn is also a factor in modern sanitation.

COÖRDINATION OF FIRE FIGHTING FACILITIES[1]

By George W. Booth[2]

The Chairman of your Publication Committee has asked me to prepare a paper of a brief general nature on some aspect of fire protection. I have chosen the above topic, interpreting it to mean the harmonizing or balancing of the various features of fire protection, of which the water supply and the fire department are the most important.

The trend of development of American cities has been a very definite factor in fire fighting practice. A new country, with large forest areas, naturally meant extensive use of wood in all construction. Also many industries and businesses were started with a minimum of capital and often with the thought of only temporary occupation of the building. All of these economic factors resulted in the adoption of forms of construction more notable for their cheapness than for their stability and ability to withstand fire. There was also an absence of restrictive laws in the form of building codes, which would have forced better construction. Even today there are few basic state regulations such as are found in some of the European countries, which require superior building construction; this permits new developments to be erected outside of cities with no supervision over the class of building.

All of the above features have added to the burden of fire fighting facilities of the country. Larger building areas, structures of increasing height and greater congestion of values have made it more and more necessary to provide large and powerful fire departments. The capacity of fire engines increased from those of one stream to those capable of delivering as many as four streams. Water towers, deluge sets, turret nozzles and other powerful stream appliances were devised to combat fires in building which constitute conflagration breeders. These developments came first in the larger cities, but many of the smaller cities and towns have equipped their fire departments with apparatus of large capacity. It is not unusual

[1] Presented before the Buffalo Convention, June 8, 1926.

[2] Chief Engineer, National Board of Fire Underwriters, New York, N. Y.

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for village volunteer fire departments to have fire engines of 1000 gallons a minute capacity, although such capacities are not normal, the usual rating of fire department pumpers being from 500 to 800 gallons a minute.

Practically all fire departments are now equipped with automobile pumping engines. With this equipment the normal fire demand upon water systems has been materially increased, as these machines are capable of delivering their full capacity for indefinite periods, which was not the case with the steam fire engine, dependent upon skillful stoking for its power and therefore seldom worked to full capacity.

All of these changes in the fire department, from the introduction of the first "hand tub" to the modern automobile pumper, have necessitated corresponding improvements in water supplies. In years past, small communities developed water works systems primarily for domestic use; sizes of mains were small and the total demand on the supply works was only that needed for consumption. With the increase in concentration of values and the realization of the economic saving which good fire defenses introduced, these small places, which were formerly satisfied with a purely domestic water system, proceeded to require that fire protection must also be provided for. Small mains, single outlet hydrants, infrequent gate valves, low pressures and single supply units are features to be avoided even in the village water supply system.

Coördination of fire fighting facilities must take into consideration the relative value of each class of service, and as a basis for such consideration it is logical to use the National Board of Fire Underwriters Standard Schedule for Grading Cities and Towns of the United States. The Schedule weights the various services as follows: Water supply 1700, fire department 1500, and fire alarm 550; for the indirect fire fighting factors, that is, proper construction and fire prevention, there was assigned a value of 1350. This was on the basis of a total of 5000 points or demerits for absence of all protection.

Application of the Grading Schedule to cities and towns during the past ten years indicates that this relation of value is well balanced. It will be noted that coördination between the various services, especially the water supply and the fire department, is essential, as these two are of about equal weight.

Any coördination must start with coöperation; close contact

between the water and fire department officials will correct many misunderstandings and result in improved operation. Probably the features of a water supply which require the greatest coördination with the fire department have to do with the actual delivery of water in and around the places of greatest hazard. Fire departments, to combat serious fires, must use large quantities of water in powerful streams; to accomplish this, hose lines must be short and yet must be concentratable at vital points; not only is it essential that the feeder mains must be able to deliver the full demand of the number of fire department pumpers which will be put into service, but there must be an additional supply available to provide for waste due to hydrants left open and other losses incidental to a large fires.

To coördinate the service of the two departments it will be necessary for the water works official to view the demands from the standpoint of the fire chief; to consider the locations of hydrants both as to size of mains which feed them and as to whether the number is sufficient to permit the necessary concentration of fire streams. A hydrant more than 700 feet away from the point of delivery of the stream is of little value. A study of this subject some years ago showed that in the average city there must be one hydrant to each 50,000 square feet of land surface, including street areas, to provide proper distribution for the usual high value mercantile and manufacturing district; this roughly means two hydrants at each street intersection, with an intermediate hydrant where blocks exceed 350 feet between street centers.

Examples of effective coöperation between departments are available in Baltimore, Detroit, New York and other cities. Mr. Siems of the Baltimore Water Department described in a paper presented to your Association in 1924 the studies on fire protection requirements, to which the chief of the Fire Department contributed his judgment and experience; Mr. Fenkell is to speak to you later in this convention on the value of flow surveys in determining locations where the supply for fire protection purposes is inadequate and the best methods of correcting the situation. It is common practice in New York for the water department to make flow tests whenever there is any question of adequacy of fire protection, and to utilize the results of the tests in planning for a strengthening of the distribution system.

The modern automobile pumper, as indicated above, has, by its

greater capacity, resulted in a larger demand being made on the water system. It has also brought about a change in fire methods and a lessening in the cost of fire service which have benefited many cities which formerly depended upon streams direct from hydrants. There is no longer the expense of keeping horses for a fire engine and hose wagon, nor is there the material cost of fuel to maintain steam in the boiler; when these costs existed it was often more economical to provide fire departments with hose wagons only and to raise pressure on the water systems. Cities have now provided most of the fire companies with pumpers in place of hose wagons; the extra cost of the pumper is warranted by the gain in effectiveness. A proper coördination of the fire fighting facilities under such conditions is to provide a normal pressure of 60 to 70 pounds, depending somewhat upon the general height of buildings; this will allow the first stream to be taken direct from the hydrant and will give good supply to automatic sprinkler systems and other private fire appliances; with such a pressure carried normally, economic design of the distribution system can be adopted and carried out and the practice of raising pressures for fires can be discontinued.

A certain amount of coördination is necessary between the water department and the fire alarm office. Where pressures must be raised or additional machinery put into operation for fires it is essential that all alarms of fire be received by the water department. In any system it is desirable for the water department to receive alarms, as some competent official should respond to all second alarm fires to render any aid desired by the fire department; and for serious fires there should be a crew, with a complete outfit of valve keys, hydrant wrenches, maps and records, so that effective shut-offs can be made or the supply increased by opening valves between pressure zones. In all large conflagrations great aid has been rendered by the water department employees closing hydrants and shutting off broken building connections.

There will doubtless be no argument as to the shortcomings resulting from a lack of coördination; a poor water supply reduces the effectiveness of a good fire department; in like manner inefficient methods or inadequate equipment in the fire department means that greater demands will be required from the water system. Other fire fighting facilities also enter into this consideration; a poor fire alarm system results in delay in receiving the alarm, with the fire gaining greater headway before the fire department responds and and consequent increased demand for water.

Improved building laws and ordinances on preventive measures are a material aid to fire fighting facilities; construction can be such as to minimize the demands on water supplies and fire departments, so that it is entirely logical to coördinate these protective activities along with the fire fighting facilities.

Private fire protection facilities are of the utmost importance; quick notification of fires means less demand for water; and speed in extinguishing a fire lightens the burden of the municipal departments. For the above reasons it is consistent that officials of water and fire departments encourage the installation of private alarm systems, automatic sprinklers, standpipes and yard hydrants; all of these are, in addition to their value to the private plant, a gain in common fire protection and a general aid in fire fighting.

Referring once more to the Grading Schedule, may I say that it provides a standard which has so commended itself to insurance inspection organizations as to bring about its almost universal adoption in the United States, thus simplifying the task of those responsible for the design, construction and operation of water work, since they may know they have only the one standard to consider in relation to fire protection.

The standards of adequacy and reliability are in the main your own; they are not something theoretical and unattainable, but were compiled from a composite of the best practice in American cities, which practice was in turn evolved as a result of long experience of the members of this Association and their predecessors.

SOCIETY AFFAIRS

MONTANA SECTION

The first annual meeting of the Montana Section was held in Butte, Montana, April 15 to 17, 1926. The members were guests of the Butte Water Company, a corporation supplying the city of Butte and its environs with water, Eugene Carroll, manager and vice-president.

The first day was taken up with registration, a trip to the Leonard Mine and a social gathering at the Silver Bow Club. The registration showed 45 members and delegates in attendance. The Leonard Mine from which copper is taken is one of the show places in the great mining camp. There were thrills aplenty for the uninitiated. The first drop of 1600 feet was sufficient to impress the guests with the seriousness of life. Further down in the bowels of the earth we saw the raw ore being ruthlessly torn away. Each man obtained a specimen of ore as a talisman.

The trip by automobile to the pumping stations, reservoirs, and shops of the water company on Friday was a revelation to all of the equipment necessary to supply the city of Butte and the mines with an ample supply of pure and wholesome water. Lunch at the Big Hole Pumping Station (on the Big Hole River) was a hilarious occasion. The ladies of the party, wives of officials and employees of the water company, added much to the enjoyment by providing the lunch. In the evening a showing of motion picture films depicting the making and use of cast iron, steel and clay pipe was the educational feature.

On Saturday the business session was held at the headquarters room in the New Finlen Hotel. The Hon. W. D. Horgan, Mayor of Butte, welcomed the group and Mr. Willett, president of the section, responded. Mr. Willett's presidential address gave a brief history of our section and of water supply development in general. It was a call to rally around the organization as one which will be a source of valuable information to all.

Reports of the secretary-treasurer and standing committees were heard. Dr. W. F. Cogswell, Secretary of the Montana State Board

of Health, congratulated the water works officials of the state on the fact that another year had passed with no typhoid fever cases arising from public water supplies. He expressed the appreciation of the State Board of Health for the splendid coöperation which exists between the water works men and the State Board.

Following a luncheon attended by ten water works men specially interested in water filtration, the afternoon session opened.

At this meeting the following technical papers were read and commented upon: "The Butte Water Supply," by Eugene Carroll; "Recent Progress in Water Works Practice," by J. A. Jensen of Minneapolis: "Water Works Financing and Accounting," by Fred Buck, engineer for the Montana Public Service Commission.

The section went on record as favoring Minneapolis as the next meeting place for the 1927 Convention of the American Water Works Association. J. F. Willett, superintendent of the Billings, Montana, water department was elected president; H. S. Thane of the Missoula Public Service Company was chosen vice-president and H. B. Foote, sanitary engineer, State Board of Health, was reelected secretary-treasurer. The next meeting place was designated as Billings, Montana.

Standing committees were appointed to work during the coming year to report at the next session. H. M. Johnson of the Anaconda Water Department was continued as chairman of the committee to study "Goiter and the Public Water Supply." Mr. Morris, city engineer and water superintendent of the Great Falls water department, will continue his study of "Algae and the Public Water Supply." In addition a committee, to be appointed, was authorized to investigate and recommend for action the subject of the type of organization best suited for Montana municipalities.

The delegates were royally entertained Saturday evening at the Butte Water Company's Social Club rooms maintained for the employees and officers of the company.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Use of Solutions of Inorganic Salts as Permanent Color Standards. M. G. Mellon. Proc. Indiana Acad. Sci. 1922, 164–71. From Chem. Abst., **18**: 1446, May 20, 1924. Review and discussion of data on color of solutions of inorganic compounds, requirements of permanent color standards, limitations of inorganic compounds for such purposes and possible combinations for permanent standards.—*R. E. Thompson.*

Determination of Chlorine in Bleaching Powder. V. Rodt. Z. angew. Chem., **37**: 38, 1924. From Chem. Abst., **18**: 1447, May 20, 1924. Great disadvantage of titration with arsenite solution in presence of excess sodium bicarbonate is that potassium-iodide-starch paper is not very sensitive. Following modification may be used if concentration of bleaching power is not too great. Titrate in usual manner until test paper no longer turns blue with drop of solution, then add to solution 1 cc. of potassium iodide solution used to prepare test paper. If concentration is not too high, solution will turn blue and titration can be continued to disappearance of color.—*R. E. Thompson.*

Indicator Reaction as a Source of Error in pH Determinations. F. W. Marsh. Science, **59**: 216, 1924. From Chem. Abst., **18**: 1447, May 20, 1924. Indicator solutions stored in glass bottles may cause variation of pH reading of 0.3 to 0.9 between adjusted and unadjusted indicator solutions. Directions for adjusting indicator solutions are: Take 20 cc. of indicator from stock bottle, place drop on spot-plate, add 1 drop of 0.5 N hydrochloric acid to the 20 cc., and place another drop on plate. Repeat until acid color is reached. Select a spot which corresponds as nearly as possible to color in middle of workable range and adjust stock indicator solution to this point by addition of calculated amount of 0.05 N hydrochloric acid. Buffer solution of desired pH plus indicator being tested may be employed, or colors in chart in Clark's book may be used for comparison. After repeating few times, "midway" color can readily be determined without preliminary 20 cc. test. Adjustment is unnecessary for highly buffered solutions.—*R. E. Thompson.*

Rust Preventive. Karl Micksch.. Apparatebau, **35**: 149–50, 1923. From Chem. Abst., **18**: 1462, May 20, 1924. Clean iron or steel object is immersed

in bath of fused sodium nitrate, potassium nitrate, or other oxygen-containing salt that is not decomposed by fusion, until protecting coating is of desired thickness; then washed and thoroughly dried.—*R. E. Thompson.*

A New Method of Welding. KARL MICKSCH. Apparatebau, **35**: 149, 1923. From Chem. Abst., **18**: 1462, May 20, 1924. One face of iron is covered with film of molten copper in atmosphere of hydrogen and other piece pressed against it. The copper penetrates the pores of the iron and holds it together. —*R. E. Thompson.*

The Corrosion of Metals. U. R. EVANS. J. Oil Colour Chem. Assoc., **6**: 150–64, 1923; **7**: 29–32, 43–7, 1924; cf. C.A., **17**: 2699. From Chem. Abst., **18**: 1462, May 20, 1924. Corrosion of ordinary metals by ordinary industrial waters requires presence of oxygen. When two sheets of commercial zinc are plunged into potassium chloride solution and one is aërated, an electric current is produced which is maintained by consumption of unaërated electrode. This explains phenomena noticed in corrosion of zinc plate half immersed in potassium chloride solution. A current is produced between upper aërated portions and lower unaërated portions; alkali is produced at former point and zinc dissolved, yielding zinc chloride at latter. Between the two membranous wall of zinc hydroxide is produced by precipitation. Thus the electrochemical view of corrosion explains fact that greatest corrosion takes place at points to which oxygen has least access. Similarly when drop of potassium chloride solution is placed on an iron surface, alkali is produced around the edge of drop to which air has access; ferrous salts produced in unaerated center, and where two meet a membrane of white ferrous hydroxide appears which later becomes oxidized to brown ferric hydroxide. A ring of clear liquid remains outside membrane, but below this ring there is no corrosion of iron although metal is distinctly eaten away inside membrane. Value of polishing, covering with metallic coatings, painting, etc., and possibility of increasing use of non-corroding alloys discussed.—*R. E. Thompson.*

A Novel Protection Against Boiler Scale. HANS TOMCZAK. Apparatebau, **35**: 235–6, 1923; cf. C.A. **16**: 1842. From Chem. Abst., **18**: 1541, May 20, 1924. Boiler shell is made cathode of an electric circuit, the anode being insulated tubes. Current of 0.02–0.04 ampere at 20–30 volts per square meter of shell surface prevents scale.—*R. E. Thompson.*

The Corrosion of Iron, Particularly Iron Conduits. An Unusual Case of Sponginess of a Casting Caused by the Mineral Water at Montdorf-État. PIERRE MÉDINGER. Rev. universelle mines, **18**: 227–30, 1923. From Chem. Abst., **18**: 1462, May 20, 1924. Based on theory that rusting of iron is accelerated by presence of more electropositive metal and retarded by more negative one, the H ion (from water) is regarded as electropositive metal which deposits on the iron and even forms an alloy with it when iron is immersed in water. Rusting, once inaugurated, continues (1) because of permanent displacement of equilibrium due to presence of dissolved salts capable of diminishing concentration and osmotic pressure of ferrous ions and

(2) owing to presence of oxygen which transforms ferrous hydroxide to less soluble ferric hydroxide and oxidizes deposited hydrogen. Since rusting increases with H-ion concentration, presence of carbon dioxide, sulfur dioxide, etc., greatly accelerates corrosion. Rusting progresses in presence of oxygen, but at retarded rate, as coating of oxides formed acts as protection as long as not detached by shock. Rate of rusting is directly proportional to H-ion concentration and inversely proportional to concentration of bicarbonates. Waters of Bocq and Modave, which are highly charged with bicarbonates, exert protective influence on conduits. In castings there are an infinite number of minute galvanic piles with iron and graphite as electrodes and therefore strong electrolytes, such as chlorides, sulfates, and nitrates, increase rate of corrosion. It has previously been proved by Médinger that such salts increase dissociation of water, and therefore more rapid rusting in presence of electrolytes is due also to increased H-ion concentration. Such salts also increase the electrolytic or solution pressure of iron, thus further increasing rusting. At Trèves, corrosion of conduits by water having H-ion concentration of 0.51×10^{-7} has been prevented by first passing water over bed of marble. At Montdorf, conduits in contact with non-oxygenated water with H-ion concentration of 1.32×10^{-7} and rich in salts became spongy and free iron decreased to approximately 4 per cent and apparent density to 1.7, although appearance was unchanged. Priority is claimed (1917) for method of calculating H-ion concentration of natural waters by formula: $(3.10^{-7}\ C)/B$, where C is p.p.m. of free carbon dioxide and B is p.p.m. of carbon dioxide in form of bicarbonates.—*R. E. Thompson.*

The Quantity of Sulfur in Rain Water. B. D. Wilson. J. Am. Soc. Agron., **15**: 453–6, 1923. From Chem. Abst., **18**: 1540, May 20, 1924. The literature reports following amounts of sulfur in pounds per acre: Pullman, Wash., 5.57; Ames, Ia., 14.89; Tennessee, 12.7–232.4; Ithaca, N. Y., 1918–19, 27.8; 1919–20, 24.6; 1920–21, 26.0; 1921–2, 33.4; 1922–23, 35.9.—*R. E. Thompson.*

A Colloid Lake at Witzenhausen on the Werra River. E. Wedekind and A. Straube. Z. angew Chem., **35**: 253, 1922. From Chem. Abst., **18**: 1540, May 20, 1924. Red color of small lake is attributed to natural colloidal solution. Hydrosol, obtained by ultrafiltration and coagulation during freezing, has following composition: silica 55.67–56.36, ferric oxide 12.01–11.99, alumina 32.66–31.58 per cent.—*R. E. Thompson.*

Industrial Water. Paul Valentin. Chimie & Industrie, **10**: 1043–4, 1923. From Chem. Abst., **18**: 1541, May 20, 1924. It is good practice to use condenser water for boilers, but use of other than waste heat for preheating feed water is uneconomical. Softening is economical when effected with chemicals, but not when effected by distillation. Precipitation chamber for chemical softening described.—*R. E. Thompson.*

Method of Preserving Chloride of Lime in India. J. W. Tomb. Indian Med. Gaz., **59**: 84–5, 1924. From Chem. Abst., **18**: 1552, May 20, 1924. For storage of calcium hypochlorite it is recommended that 4-gallon jars of glazed

earthenware, similar to those commonly used in Indian shops for storage of tobacco, be used. Cover of jar rests on an asbestor ring and is secured by iron screw clamp, point of screw resting on plug of lead in top center of cover. —*R. E. Thompson.*

Caporiet and Liquid Chlorine. J. VERSLUYS. Arch. Suikerind, **32**: 70–1, 1924; cf. C.A. **17**: 3393. From Chem. Abst., **18**: 1553, May 20, 1924. "Caporiet" is a calcium hypochlorite with 50 per cent active chlorine. In Java, chlorine in this form is twice as expensive as liquid chlorine. "Pregolan," with 65–72 per cent active chlorine, furnishes chlorine at slightly lower cost than liquid chlorine.—*R. E. Thompson.*

Interpretation of Flue Gas Analysis. F. D. HARGER. Combustion, **10**: 115–7, 1924. From Chem. Abst., **18**: 1559, May 20, 1924. In typical case, with 40 per cent excess air, carbon dioxide percentage is 13.0 with complete combustion but only 11.8 when 1.1 per cent carbon monoxide is present, loss being 13.44 and 18.31 per cent respectively. This demonstrates unreliability of carbon dioxide readings as sole guide of excess air admission. Most efficient operation can be secured not by obtaining the highest percentage of carbon dioxide, but by obtaining highest carbon dioxide without forming carbon monoxide or other combustible gases.—*R. E. Thompson.*

The Process of Combustion in Powdered-Coal Firing. W. NUSSELT. Z-Ver. deut. Ing., **68**: 124–8, 1924. From Chem. Abst., **18**: 1559, May 20, 1924. Process of combustion may be divided into two parts: (1) raising of particle to ignition temperature, and (2) actual combustion of particle. Ignition temperatures of various solid fuels as given by Holm (C.A. **7**: 3215) and Sinnat and Moore (Ibid. **65**: 1289, 1921) do not agree very closely, but they are all quite evidently much below those of mixtures of combustible gases which ignite spontaneously between 500 and 600°. In solid fuel the degasified carbonaceous residue most probably acts as catalyst and thus lowers ignition temperature. Actual burning of particle is problem in diffusion, since it depends entirely upon rate at which oxygen can come in contact with surface.—*R. E. Thompson.*

The Utilization of Flue Gases of Boiler and Drying Plants for Increasing the Efficiency of Furnaces. H. CLAASSEN. Arch. Warmewirtschaft, **4**: 201–3 1923; cf. C.A. **18**: 161. From Chem. Abst., **18**: 1559, May 20, 1925. Claassen proposes to take flue gas from one boiler and blow it into combustion space of 2 or 3 other boilers. This would much improve mixing of gases and enable less excess air to be used without losing unburned gases at stack. A 6 per cent saving in fuel would be attained. He also described use of flue gas under back part of chain grate, where most of excess air enters furnace. Tests of this plan showed saving of 5 per cent.—*R. E. Thompson.*

The Estimation of Lead in Potable Waters. J. C. THRESH. Analyst, **49**: 124–8, 1924. From Chem. Abst., **18**: 1627, June 10, 1924. Presence of traces of copper, such as are likely to be present in distilled and in many natural

waters, often interferes with colorimetric determination of lead as lead sulfide. Recommended that 2 cc. of following solution be added before introducing hydrogen sulfide: 30 cc. Brit. Pharm. acetic acid, 70 cc. copper-free distilled water, and 0.1 g. "gold leaf" gelatin. Filter paper is likely to contain 0.01 per cent lead.—*R. E. Thompson.*

Endemic Goiter. W. D. KEITH. Can. Med. Assoc. J., **14**: 284–9, 1924. From Chem. Abst., **18**: 1701, June 10, 1924. Data on extreme prevalency of goiter in Pemberton Valley, B. C., given. District is virgin soil and has remarkably pure water supply. Marine's procedure of iodine administration gave immediate results. Excess iodine appears to cause loss of fecundity in animals.—*R. E. Thompson.*

Chloramine Treatment of Water in the Field. C. H. H. HAROLD. J. Royal Army Medical Corps, **68**: 115–119, 1926. Experiments conducted at recent manœuvres in vicinity of Aldershot showed that use of chloramines gave satisfactory results without the objectionable tastes met when calcium hypochlorite was employed. Water containing Bact. coli in 0.01 cc. was treated and afterwards failed to show the organisms in 100 cc. A special sparklet bottle with bulb of Cl was used for preparing Cl solution and 1 gram tablets of ammonium carbonate supplied the NH_3. In practice 1 tablet of ammonium carbonate is added to 4 to 6 gallons of water in the sterilizing kettle, followed by one measure of Cl water containing the calculated amount of Cl. This is poured into a water cart three-quarters full and the mixing is obtained by filling the cart. The tablets deteriorate on exposure to the air.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Further Investigations into the Sterilization of Water by Chlorine and Some of Its Compounds. C. H. H. HAROLD. J. Royal Army Medical Corps, **45**: 190–207; 251–273; 350–363, 1925. Addition of NH_3 to water being treated with Cl_2 water results in less rapid disappearance of the Cl and more effective treatment of the water. There is less trouble with odors. The manner of addition of the chemicals usually was to pour the calculated amount of NH_3 solution onto the surface of water in an army water cart, count ten, and pour on the calculated amount of Cl solution. The amounts of NH_3 were from one-quarter to one-half the amounts of chlorine.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Wife of Hotel Proprietor a Typhoid Carrier. Editorial, Health News, N. Y., **2**: 191, 1925. Carrier had "malaria" in 1891 and had not been ill since. Five cases of typhoid fever traced to this source.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Hospital Discovers Unusual Source of Water Pollution. Editorial. Health News N. Y., **3**: 76, 1926; State Bul. Bd. of Charities, Mar. 8, 1926, Instrument sterilizer filled with infected instruments suddenly emptied itself of water. Lowering of pressure in pipes had caused water to siphon back into water pipes. Suggested remedy is to install intake above outlet, or provide automatic cut-off valve.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The "Hydrautomat" a New Apparatus for Lifting Water. Ch.D. Le Genie Civil, **87**: 443–5, 1925. Description of English device to raise portion of the water by means of a slight variation in head in a stream. See also Water and Water Eng., **27**: 483–7, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Control of the Distribution of Potable Water: a Consideration of the Existing Conditions and a Proposed Improvement. W. Silberschmidt. La Technique Sanitaire, **20**: 229–233, 1925. Discusses a number of epidemics of acute enteritis and typhoid fever. Recommends frequent examinations and official control.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Economy of Boiler Water Heaters in Feeding Steam Boilers. Editorial Le Genie Civil, **87**: 359, 1925. Apparatus of Gabarino, of Milan, is described. This apparatus consists of a boiler with an inner tube closed at one end into which cold feed water is led by a delivery pipe entering the open end of the inner tube and reaching nearly to its closed end. This water is withdrawn again from the boiler at the open end after having been made to pass in this way from end to end of the inner tube and back again. Advantage is claimed for the device since any attack by liberated gases will be on the inner tube and not on the boiler and better circulation and more uniform heating result. —*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

The Influence of Excess Air on the Proportion of Unburned Material in Industrial Combustion. Anon., Le Genie Civil, **87**: 195–6, 1925. Best proportion is not the theoretical 19 per cent CO_2 in the flue gas; on the contrary, it is necessary to admit enough air to keep the CO_2 in the neighborhood of 14 per cent since at higher percentages of CO_2 a certain amount of CO appears in the gases and offsets the effects of more complete oxygen utilization. Theoretically, the amount of unburned material should be zero. Practically, this requires excess air to an unprofitable degree. Best results are obtained with 35 to 40 per cent of excess air corresponding to 16 to 18 per cent of unburned material.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Our Actual Knowledge of the Microbiology of the Soil. Lucien Leroux. Revue generale des Sciences, August 1925; Le Genie Civil, **87**: 335–6, 1925. Stoklasa estimates active bacteria at 200 to 300 kg. per hectare at an average depth of 40 cm. CO_2 produced amounts to about 150 kg. per hectare per day and is accompanied by a rise of 1 to 2°C. Acids secreted by bacteria are neutralized by $CaCO_3$. The action of the bacteria ultimately brings about complete combustion of organic matter. Nitrogenous matter is hydrolyzed with the production of NH_3. Nitrogen is fixed by anaërobic and aërobic bacteria at rate of 17 to 45 kgm. per hectare per day. Oxidation of NH_3 normally yields NO_3, which may then be reduced if soil becomes water logged. Sulphur is normally oxidized.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Four Cases of Typhoid in One Family Caused by Swimming in an Infected Stream. Editorial, Health News N. Y., **2**: 190, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Elimination of Iron From Water. B. DEUTSCH. and Ges. fur. chem. Produktion m.g.H. (E.P. 216, 128, 13.5.24. Conv., 14.5.23). Chem. and Ind., **44**: B 145, March 6, 1925. The water is mixed with active charcoal and subsequently filtered, whereby iron and finely suspended impurities are removed. Reference is directed in pursuance of Sect. 7, Sub-sect. 4, of the Patents and Designs Acts, 1907 and 1919 to E.P. 188, 667 and 155, 610.). D.G.H.—*A. M. Buswell.*

Effluents from Ammonia Plants and Their Disposal. T. LEWIS BAILEY, Ph.D., F.I.C. (Of the Ministry of Health). Chem. and Ind., **44**: 835, Aug. 21, 1925. The origin of the effluents, at any rate in England, is essentially two-fold: viz., the treatment of ammoniacal liquors produced at (a) coke ovens and (b) gas works: in each case the carbonization of coal gives rise to the constituents of the ammoniacal liquor, which itself is produced by first cooling the crude gas and then scrubbing it with water.—*A. M. Buswell.*

Water Purification. F. DIÈNERT. Compt. rend., **180**: 1228–1229, 1925. Chem. and Ind., **44**: B 421, June 12, 1925. Water may be rendered sterile by standing over ferrous sulphide under anaerobic conditions; this method of sterilisation probably occurs in the subsoil giving rise to pure subterranean waters containing no dissolved oxygen or nitrates, but possible traces of hydrogen sulphide. Biological surface filters take a considerable period to become accustomed to the water with which they have to deal. Thus in 60 days the percentage of Bac. coli removed from a water rose from 24 to 94 per cent. Similar results were obtained with water containing ammonia and with one containing phenol. The method of acclimatizing filters for the removal of particular substances may be applied to the purification of trade effluents. L. F. H.—*A. M. Buswell.*

Cleaning Sand Filters of Large Surface. A. SIVADE. E.P. 205, 818, 19.10.23 Conv. 20.10.22. Chem. and Ind., **43**: B 652. A rectangular frame or caisson is lowered over the portion of filter-bed to be cleansed, its lower edge being allowed to project slightly into the sand to form a reasonably watertight joint. Within the frame are hung a number of counterbalanced vertical injection pipes which when supplied with clean water by a pump descend so that their lower open ends are buried in the sand and a uniform stream of cleansing water flows upward. Another pump together with a system of collecting pipes is provided to withdraw the foul water and sludge but not the sand. The caisson and piping therein may be carried by a pontoon which may contain the pumps, machinery, etc., so that the filter bed need not be drained dry for cleansing purposes, the sand bed being treated portion by portion till the whole is cleansed. The withdrawal and injection pipes are arranged in "isobaric rows," i.e., the water pressure is equal at all orifices of a set, so as to obtain uniform washing over the whole area. This is effected by suitable proportioning of the header piping. B.M.V.—*A. M. Buswell.*

Iron Deposit in Cast Iron Pipes. J. R. FOFF. Surveyor, **66**: 465–466, 491–492, 509–510; Chem. and Ind., **44**: B 261, April 17, 1925. An incrustation which

formed in cast iron pipes conveying soft water from the Pennine range was found to consist chiefly of iron bacteria. In discussion on the paper, the consensus of opinion was that nodule formation usually occurs in the vicinity of perforations in the pipe coating. The use of cement-lined pipe reduces incrustation. Sodium silicate treatment is very effective in preventing corrosion of water-pipes, particularly of lead. The composition of the nodules was: moisture 44.9 per cent; calcium sulphate, 3.33; magnesium, trace; silica, 0.55; carbonates, nil; ferric oxide 39.32; ferrous oxide 12.90; the last figure is probably a little low due to oxidation. R.E.T.—*A. M. Buswell.*

Porosity and Intensive[1] Corrosion Experiments on Commercial Sheet Zinc and Other Materials. Ulick R. Evans. Chem. and Ind., **45**: 37T, February 12, 1926. The corrosion of commercial zinc sheet, partly immersed in chloride or sulphate solution is of four types, all explicable on the differential aëration principle: (1) Regional corrosion of the lowest part, where oxygen, first becomes exhausted; this region becomes anodic to the part above. The sharp boundary separating the attacked and unattacked regions is usually horizontal, and moves steadily upwards. (2) Point corrosion, believed to be due to capillary channels opening on to the surface; and "evacuation treatment," designed to allow the liquid to enter capillary openings, is found to accelerate the appearance of point corrosion. (3) Line corrosion, along old scratch-lines and (4) Edge-point corrosion along the cut edges of the specimens. Scratches and cut edges represent places where the entrance of the liquid into internal channels will be easiest. Under certain conditions point corrosion may "spread" to a more general and less dangerous form of attack. It is believed that the capillary channels known to exist in all metals are one of the most frequent causes of intensive corrosion. Not only do they determine the location of pitting at points where they reach the surface but they are probably responsible for the rottenness, due to deep-seated internal attack, which is so serious a feature of atmospheric corrosion in the presence of acid fumes.—*A. M. Buswell.*

Chemical and Physical Processes in Rusting and Corrosion. O. Bauer. Gas- u. Wasserf., **68**: 683–687, 704–707, 1925; Chem. and Ind., **45**: 57, January 22, 1926. Review of the subject, with special reference to the work of the author and his colleagues (cf. Heyn and Bauer, J., 1908, 569; 1910, 568; Bauer and Wetzel, 1916, 1112; Bauer and Vogel, 1919, 1444A; Bauer, B. 674, 1925.) A. Coulthard.—*A. M. Buswell.*

Fallacy of the Test for Lactose Fermenters as an Indicator of Fecal Pollution of Waters. O. Schobl and J. Ramirez. Phillipine J. Sci., **27**: 317–324, 1925; Chem. and Ind., **44**: B 898, November 13, 1925. A recommendation to close a number of public artesian wells in Manila on account of presence therein of lactose fermenters led to an investigation which showed that the lactose

[1] The word "intensive" is here used to cover ordinary pitting, and also the internal attack which causes loss of strength within an article, whilst producing no very conspicuous changes on the surface.

fermenters were derived from hemp packing and leather washers of pumps employed. New unused packing and washers were also found to contain lactose fermenters. The waters were found to be free from true B. coli. Comparative tests for B. coli strains failed to yield any criterion for the differentiation of B. coli of human origin and B. coli of animal origin, and indicated that under natural conditions the pollution of water by B. coli originating from the feces of water-living animals such as fishes, frogs, and insects is not likely. W.T.L.—*A. M. Buswell.*

Water Filters. D. Hall, J. H. Kay, and Hall and Kay, Ltd., (E.P. 240, 211, 19.6.24). Chem. and Ind. **44:** B 968, December 11, 1925. A filter for water to be used in sprayers or humidifiers in textile mills and similar places, consists of a fixed casing within which is a cylindrical filter chamber capable of being rotated. When the filter becomes clogged the cylinder is rotated several times, whereby the filter bed is broken up by means of horizontal rods in the cylinder or by means of paddles attached to the central shaft. C.O.H. —*A. M. Buswell.*

Filtering or Sterilising Liquids (Water). H. E. Potts. From N.V. Algem. Norit Maatschappij (E.P. 234,149, 20.12.23). Chem. and Ind., **44:** B 611 August 6, 1925. Sterile liquids, especially water, may be produced by running them through layer of carbonaceous material having a microscopic fibrous structure derived from the raw material and previously sterilised by means of an innocuous acid preferably in the gaseous state (excluding boric acid), e.g., hydrochloric acid, the excess of which is washed out. (Reference is directed, in pursuance of Sect. 7, Sub.-sect. 4 of the Patents and Designs Acts, 1907 and 1919, to E.P. 198,373). D.G.H.—*A. M. Buswell.*

Corrosion of Cast Iron by Buenos Aires Tap Water. C. F. Hickethier. Anal. Assoc. Quim. Argentina, Chem. and Ind., **44:** B 333, May 15, 1925. Corrosive action of the individual salts present was studied by determining loss in weight per 100 square centimeters of pieces of cast iron immersed in solutions corresponding in concentration to the partial concentrations of the salts in the tap water. No very marked differences in corrosive action were observed. G.W.R.—*A. M. Buswell.*

Origin of Pitting; Corrosion Phenomena in Iron Water Pipes. E. Liebreich. Korrosion u. Metallschutz, 1: 67–69, 1925; Chem. Zentr., **96:** II., 2024, 1925; Chem. and Ind. **45:** 57, January 22, 1926. Formation of corrosion pits in iron water pipes cannot be due to difference in the concentration of salts in main water stream and in pit, as corrosion products have an alkaline reaction. A probable reason for formation of pits is the perforation of the protective coating of rust inside the tube owing to presence of chlorides or other impurities, followed by occlusion in the rust of the hydrogen set free by the action of the exposed electrolytic cell, hydrogen-electrolyte-iron, which causes rapid corrosion of the iron locally. A. R. Powell.—*A. M. Buswell.*

In What Chemical Form Does Silicic Acid Exist in Water? W. Windisch. Woch. Brau., **42**: 59, 1925; Chem. and Ind., **44**: B 522, July 10, 1925. A silicious water containing, per 100,000 parts, 34.5 parts of carbonates, including 22.5 parts of sodium carbonate, after subjection to electro-osmosis, contained only about 1 part of alkaline-earth carbonate and 2.5 parts of sodium carbonate, the content of N_2O_5 being reduced from 4.21 to 0.18. A good brewing water is thus produced from one useless for such purpose. The fact that, despite variations in the conditions of the electro-osmosis, the silica content of the water remained virtually unchanged, shows that the silica is present as SiO_2 and not as a silicate. T.H.P.—*A. M. Buswell.*

Water Analysis. J. Zink and F. Hollandt. Z. angew. Chem., **38**: 445–446, 1925; cf. B 844, 1924; Chem. and Ind., **44**: B 522, July 10, 1925. In tabulating results of an analysis of water it is suggested that each anion be distributed amongst the various cations in proportions based on relative number of chemical equivalents of each of these present. This procedure has the advantage of giving an indication of the possible salts and so is of value for technical therapeutic considerations. D.F.T.—*A. M. Buswell.*

Transparency of Natural Waters Towards Ultra-Violet Rays. J. Duclaux and P. Jeantet. Compt. rend., **181**: 630–631, 1925; Chem. and Ind., **44**: B 1009, Dec. 25, 1925. A 10 cm. layer of pure water is transparent as far as λ = 1900 A° and mineral salts do not interfere with this transparency. Polluted water and water containing ammonia or proteins can be readily distinguished from pure water, but waters containing nitrates and nitrites are indistinguishable spectrographically. Rain water is inexplicably opaque. L.F.H.—*A. M. Buswell.*

Determination of Dissolved Oxygen in Water in the Presence of Nitrous Acid. G. Alsterberg. Biochem. Z. **159**: 36–47, 1924. Chem. and Ind., **44**: B 940, November 27, 1925. Nitrous acid, which causes considerable errors in determination of dissolved oxygen by Winkler's method, may be removed by sodium azide. When present in a concentration 0.0001 per cent (as when dealing with biological material) a sufficient quantity of azide is added to the sulphuric acid solution of manganese hydroxide precipitate. If nitrous acid is present in greater concentration, the azide is added in a concentration of 0.5 per cent simultaneously with the alkaline potassium iodide solution at the commencement of the determination. E.C.S.—*A. M. Buswell.*

Determination of Dissolved Oxygen in Water in the Presence of Nitrite. M. E. Stass. Chem. Weekblad, **22**: 584–585, 1925; Chem. and Ind., **45**: 110, February 5, 1926. The various methods described in the literature are criticised, and that of Alsterberg (B., 1925, 940) is recommended as most accurate and convenient.—S. I. Levy. Cf. preceding Abstract.—*A. M. Buswell.*

Tromsdorff's Reagent for Nitrites in Water. A. Coquillat. Anal. Fis. Quim., **22**: 523–544, 1924; Chem. and Ind., **44**: B 261, April 17, 1925. A convenient modification of the Tromsdorff reagent is prepared, using 1 g. of solu-

ble starch, 10 g. of potassium iodide, and 20 g. of sodium chloride, boiling with water for one hr., and finally making up to one litre. The replacement of the zinc chloride of the original formula by sodium chloride renders reagent more stable. The delicacy of the reaction is affected by dissolved oxygen. When the water used is saturated with air the intensity of the coloration is proportional to the amount of nitrite present. This proportionality does not hold when the oxygen has been removed by a current of carbon dioxide. Use of acetic acid with the reagent is recommended on account of its freedom from nitrogen oxides. G.W.R.—*A. M. Buswell.*

Color Reaction for Detecting Nitrites in Water. H. Stoof. Z. anal. Chem., **64**: 272–273, 1924; Chem. and Ind. **43**: B 728, September 5, 1924. Detection of nitrites in water by the addition of aqueous solution of neutral red (cf. Zlataroff, J., 1923, 677 A) is not sufficiently definite to be accurate when free sulphuric or hydrochloric acid is present. Nitrates, which are usually present in greater proportion than nitrites in potable waters, intensify the color in presence of sulphuric acid, giving a color corresponding to a higher porportion of nitrite than is actually present. Dissolved organic matter oxidisable by permanganate, ferric, ferrous, and manganous salts also disturb the reaction, which fails completely in presence of free acetic acid. The detection of nitrites in waters is only completely satisfactory in phosphoric acid solution. To 10 cc. of the water to be tested are added 2 cc. of a 0.002 per cent aqueous solution of neutral red and 4 cc. of a 25 per cent solution of phosphoric acid: the reaction requires 3 to 4 minutes, and the limit of sensitiveness is 0.2 mgm. per litre. J.B.F.—*A. M. Buswell.*

Hydrostrychnine Reagent for Determining Nitrites and Nitrates in Water. I. M. Kolthoff. Chem. Weekblad, **21**: 423–424, 1924. (Cf. Denigés, J. 1911, 827); Chem. and Ind., **43**: B 886, October 31, 1924. Nitrites should be determined colorimetrically before addition of sulphuric acid, and an equal quantity added to the blank in the nitrate determination. Other oxidising agents interfere. Ferric iron may be removed by means of sodium bicarbonate. (Cf. A, November). S.I.L.—*A. M. Buswell.*

Uncertainty of the Determination of Nitrous Acid in Surface Waters by the Feldhaus-Kubel Method. S. Vagi. Z. anal. Chem., **65**: 436–438, 1925; Chem. and Ind., **44**: B 375, May 29, 1925. Determination of nitrite content of surface waters by treating them with magnesium sulphate and sodium carbonate at 15°, followed by titration of the filtrate with permanganate, usually yields results which are much too high owing to the reducing action of certain organic constituents of the water. Accurate results are obtained only if the filtrate is distilled with acetic acid and the distillate titrated with permanganate. A.R.P.—*A. M. Buswell.*

The Action of Natural Waters on Metallic Copper. Herbert Henstock. Chem. and Ind., **44**: 219T, May 8, 1925. For most practical purposes, action of pure water on copper is negligible, although according to Abel (Z. Elektrochem., 1913, **19**: 477) minute trace—as little as 0.00004 per cent—may

occur in distilled water (cf. Mayer and Schramm, Z. anal. Chem., 1917: 56: 129; Pincheon, Compt. rend., 1912, 154: 865). Minute quantities have also a bactericidal action. Skinner (J. Amer. Soc., 1906, 28: 361), has shown that copper is injurious to plant life even when the soil contains large quantities of magnesium and calcium bicarbonates, and that copper, in contact with solutions of these salts is dissolved at ordinary temperatures is less than 48 hours. Metallic copper, coming into contact with waters containing certain salts and organic matter, may therefore assume an importance which is not often attached to it, both in potable and other waters where copper apparatus is in use or in the soil where pieces of this metal may have become buried.—*A. M. Buswell.*

Detection of Copper in Distilled Water. G. Poirot. J. Pharm. Chim., 30: 393–399, 1924; Chem. and Ind., 44: B145, March 6, 1925. To 0.2 cc. of a 10 per cent solution of pure guaiacum resin (purified by dissolving in alcohol, filtering, and evaporating) in pyridine, mixed with 3 drops of oxygenated water (prepared by tenfold dilution of 100-vol. hydrogen peroxide with twice distilled water) and 10 cc. of 95 per cent alcohol, are added 10 cc. of the water to be tested. A characteristic blue coloration is produced if copper is present, the limit of sensitiveness being 1 part of copper in 10 million parts of water. The resin solution should be kept in a yellow bottle with ground-in stopper. W.T.K.B.—*A. M. Buswell.*

Colorimetric Determination of Small Quantities of Lead and Copper in Drinking Water. C. Pyriki. Z. anal. Chem., 64: 325–330, 1924; Chem. and Ind., 43: B 845, October 17, 1924. Winkler's sulphide colorimetric method (J. 1913, 157) gives good results for lead when copper is absent and for lead in quantities less than 25 mg. per litre when copper is present. As copper sulphide is more strongly colored than lead sulphide, the values obtained for copper by comparison against a lead standard must be multiplied by 0.813 for correct results. When the lead exceeds 2.5 mgm. per litre lead cyanide separates on addition of potassium cyanide and low values are consequently obtained for lead. The ferrocyanide-sulphide method of Winkler (loc. cit.) gives good results for copper and lead under all conditions. A.R.P.—*A. M. Buswell.*

Electrical Conductivity of Mineral Waters as a Means of Control. W. Kopaczewski and M. Bem. Compt. rend., 178: 2117–2120, 1924. Chem. and Ind., 43: B 764. September 19, 1924. Mineral waters may be classified into four groups according to whether their conductivity is high ($40–80 \times 10^{-4}$ medium (below 30×10^{-4}), low (below 10×10^{-4}) or insignificant. The change produced by loss of gas on standing or boiling is very small and results obtained with different samples of the same water are concordant. Synthetic waters of same chemical composition differ considerably in conductivity from natural waters. L.J.H.—*A. M. Buswell.*

Conductivity of Water. F. Bordas and F. Touplain Ann. Falsif., 17: 516–25, 1924; Chem. and Ind., 44: B 187, March 20, 1925. The chief varia-

tions in the conductivity of water are due to dissolved gases, especially to carbon dioxide. Ordinary distilled water varied in conductivity between 0.46×10^{-6} and 0.31×10^{-6}. Pure water may be obtained by freezing, or by distilling over calcium carbonate, using a tin or silver condenser coil (as next best to platinum), and receiving the middle distillate in quartz, pyrex, or paraffined glass. Carbon dioxide dissolved in pure water gives a maximum conductivity of 4×10^{-6}; dissolved in an electrolyte it gives an average conductivity of 3.5×10^{-6}, but when as much as 300 mgm. of a salt are present per litre the dissolved gas does not affect the conductivity. Boiling will not get rid of all the dissolved carbon dioxide, either from water or salt solution. D.G.H.—*A. M. Buswell.*

Examination of a Small Quantity of Water. G. MEILLÈRE. Ann. Falsif., **17**: 524–527, 1924; Chem. and Ind., **44**: B 187, March 20, 1925. Five cc. of water suffice for tests on color, odor, taste, and limpidity; freezing-point, refractive index, and conductivity need but a small quantity and give valuable information as to the category in which to place the water. Of chemical tests the most important are determinations of total solids and of sulphated residue. 100 cc. of water are evaporated in a small platinum crucible, the residue is dried, weighed, (the appearance will indicate any excess of organic matter) gently calcined, and the inorganic residue weighed. The alkalinity of the extract is determined with N/5 or N/10 acid (hydrochloric, if sulphates are to be subsequently determined) with alizarin red as indicator, after warming, the solution is rendered neutral with N/5 ammonia solution, the correction made and the alkalinity of the water returned as calcium or sodium carbonate. In subsequent determination of the sulphated residue slight excess of sulphuric acid is helpful to decompose any chlorides and alizarin color. Chlorides are not present in many waters in sufficient quantity to allow of their determination on small samples. D.G.H.—*A. M. Buswell.*

Determination of Nitrate in Water by Grandval and Lajoux's Method. K. SCHERINGA. Pharm. Weekblad, **61**: 995–998, 1924. Chem. and Ind., **43**: B 886, October 31, 1924. The test is best carried out in alkaline solution, and when making the blank determination an amount of sodium chloride equivalent to the chloride found in the sample of water should be added; the phenolsulphonic acid should have been prepared not less than 24 hours nor more than one week previously. (Cf. A., ii, 699). S.I.L.—*A. M. Buswell.*

Stream Pollution and Oxygen Balance. Anon. Public Works, **75**: 95–99, 1926. Methods of calculation used by committee of engineers in estimating future conditions of Illinois River in connection with Chicago's withdrawal of water from Lake Michigan are explained. Oxygen balance at any station is the difference between dissolved oxygen and total oxygen demand. The direct influences upon the oxygen balance between two river points are oxygen producing organisms, sedimentation of suspended solids, floating sludge, re-aëration, and oxygen demand exerted by sludge deposits; the indirect influences are temperature, turbulence, time of flow, area of water surface, and oxygen concentration. Effect of oxygen producing organisms was considered

negligible for the Illinois. Re-aëration rates corresponding to the dissolved oxygen saturation deficiency and directly proportional to the velocity, (because turbulence increases with velocity) were applied. The difference between the estimated dissolved oxygen from re-aëration and the change in oxygen balance in a given stretch was taken as the oxygen demand exerted by sludge deposits (neglecting the effect of sedimentation). The improvement in the oxygen balance due to sedimentation was calculated as the difference between the total oxygen demand of the settled solids and one half the oxygen demand for the time of flow through the stretch of these solids had they remained in suspension.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Filter Plant Operation. AUGUST V. GRAF. Eng. & Cont., **65**: 85–7, 1926. Can. Eng., **50**: 249–50, 1926. Factors for successful operation of a plant are the design, quality of the raw water, and care exercized in operation. Thorough coagulation is also a requisite. Washing the filter is recommended when loss of head is two feet below that at which rate would drop off. Filter surface should be examined regularly and mud balls removed. Where softening is practiced, the coating of calcium and magnesium salts may be partially removed by jetting the sand against screens. Chlorination is recommended regardless of quality of filter effluent.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Boonville Water Works. Anon. Public Works, **57**: 128–31, 1926. Boonville, Indiana, water supply is taken from two 16-inch and two auxiliary 10-inch wells, all about 50 feet deep, located 7 miles from city. There are two pumping stations at the wells, one equipped with 800-g.p.m. four-stage pump for 250-foot head and the other with 600-g.p.m. two-stage pump for 160-foot head and single-stage 90-foot head pump arranged to be run in series. These pumps deliver the water through 6 miles of 12-inch cast iron pipe to a 1.5-million-gallon reservoir. Another pumping station which practically duplicates the equipment at the wells is located between storage reservoir and the 100,000-gallon service reservoir located at town. The equipment described permits flexible and economical operation for domestic supply purposes and for meeting fire requirements.—*C. C. Ruchhoft.*

Pitting—A Myth or a Menace. D. A. STEEL. Rwy. Age, **80**: 8, 467, 1923. Detailed survey of Railway investigation reports since 1867 reveals progress being made in eliminating corrosion of boiler steel. Events considered responsible for improvement in conditions shown during last decade are: (1) overthrow of CO_2 theory of pitting; (2) confirmation of electrolytic theory of corrosion; (3) appreciation of effects of high Na_2SO_4 concentrations which were formerly considered "neutral" except in foaming; (4) wide recognition of inhibitive effect of excess NaOH. The quality and care of material are also important. Lack of records and chance in location of power constitute obstacles in solving individual cases. Where railroads are properly organized and manned, control of pitting conditions is largely a question of economics. Illustrations are shown of typical conditions.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Compressed Air Plant on Cars Used to Test Wells. C. L. Eldred. Rwy. Engineering and Maintenance, **22**: 1, 25, 1926. Many wells drilled by the A. T. and S. F. RR. in the Southwest range from 1000 to 2500 feet deep. Machinery for testing consists of one 120-pound per square inch compressor and one 450-pound per square inch unit driven by gasoline engines, all mounted on a 40-foot flat car. Plan and sectional diagrams are shown.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Corrosion Can Be Controlled. Anon. Rwy. Review, **78**: 7, 383, 1926. Editorial comment on discussion by Dr. R. E. Hall at Midwest power conference on boiler water conditioning, noting that corrosion of boiler surfaces in contact with water is electro-chemical and that hydroxyl (OH) is a satisfactory inhibitive.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Boiler Pitting. R. C. Bardwell and G. H. Emerson. Rwy. Age, **80**: 20, 1056, 1926. Comments on article by D. A. Steel. "Pitting—A Myth or a Menace" indicate 176 possible situations that can be developed from the fundamental factors which influence locomotive boiler corrosion. Tests with de-aërating feed water are being conducted on the B and O. RR.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Progress is being Made in Arresting Boiler Pitting. C. R. Knowles. Rwy. Age, **80**: 22, 1196, 1926. Comments on article by D. A. Steel, "Pitting—A Myth or a Menace," indicate that corrosion can be controlled by application of known remedies to individual cases instead of by reliance on one form of "cure-all."—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Pitting Deserves Attention. J. F. Raps. Rwy. Age, **80**: 23, 1248, 1926. Comments on article by D. A. Steel, "Pitting—A Myth or a Menace," indicate that corrosion of locomotive boilers is now a troublesome feature from boiler maker's standpoint. Front end pitting can be overcome by increased circulation, more frequent boiler washing, or application of long shims. Slight scale coating is sometimes advisable.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

Great Northern Reduces Pitting of Locomotive Boilers. Anon. Rwy. Age, **80**: 18, 951, 1926. Analyses of detailed shop work reports of approximately 125 engines on the Great Northern Railway operating between Williston, N. D., and Cut Bank, Mont., over a period of 14 years, demonstrate that changes in water treating methods have yielded striking results, with mileage doubled and tube life trebled. Raw waters on this district carry from 10 to 135 grains per gallon scaling mater, while treated waters show 3 or less, but contain from 30 to 250 of alkali salts, principally Na_2SO_4. Former treatment used $FeSO_4$ to remove excess alkalinity in order to obviate after precipitation in branch pipes. Research investigation at Montana State College developed that the electrolytic action of high Na_2SO_4 concentration could be largely inhibited by excess NaOH. During past five years excess of NaOH of approximately 10 grains per gallon has been carried at all water stations on

district affected, with practical elimination of pitting and corrosion troubles. $FeSO_4$ is used only in lowest quantity consistent with proper coagulation. Regular operation with concentrations, of alkali salts to 700 grains per gallon have caused no serious trouble or delay from foaming. Complete charts on water quality and boiler statistics are included.—*R. C. Bardwell.* (*Courtesy Chem. Abst.*)

NEW BOOKS

Études sur les combustibles solides, liquides, et gazeux. P. Mahler. 3rd. Edn., revised and enlarged, 8 vo., 108 pages with figs., Librairie polytechnique Ch. Béranger, Paris and Liège. Noted in Le Genie Civil, **87**: 452, 1925.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)

Distillation et rectification des liquides industriels. Ch. Mariller. Dunod, publisher, Paris, 731 pages, 144 figures, Noted in Le Genie Civil, **88**: 28, 1926.—*Jack J. Hinman, Jr.* (*Courtesy Chem. Abst.*)